
Soil Survey

Mason County Michigan

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SOIL SURVEY OF MASON COUNTY, MICHIGAN

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United States Department of Agriculture, Bureau of Chemistry and Soils,
in cooperation with the Michigan Agricultural Experiment Station

COUNTY SURVEYED

Mason County is in the western part of the Lower Peninsula of Michigan (fig. 1). It is bounded on the west by Lake Michigan. Ludington, the county seat and largest town, is about 100 miles northwest of Grand Rapids, 250 miles northwest of Detroit, and 80 miles by boat north-east of Milwaukee, Wis. The land area is 494 square miles, or 316,160 acres.

The county lies within the glaciated part of the United States. It includes three main topographic and physiographic divisions. The first is a broad smooth plain which comprises about 70 percent of the land area. The second, smaller in extent but a conspicuous feature of the landscape, consists of a line of dunes. This dune area extends

in a narrow belt from south to north across the county, along the shore of Lake Michigan, and ranges in width from one-fourth mile to nearly 3 miles, the widest part being west of Hamlin Lake. The dunes rise from 50 to 100 feet above the lake and adjacent plain, in

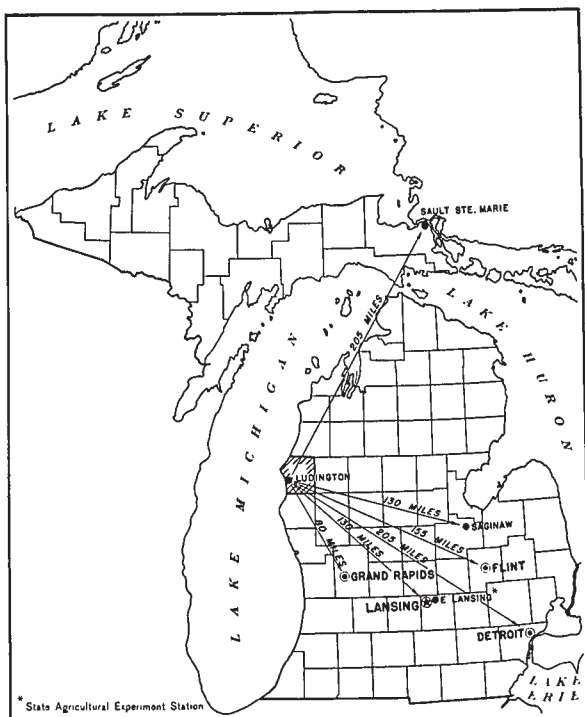


FIGURE 1.—Sketch map showing location of Mason County, Mich.

most places in the form of rounded hills, rolling and hummocky parallel ridges with intervening valleys. The third physiographic division consists of morainic areas rising above the main plain to a height ranging from a few feet to 150 feet. The most rugged morainic area is in the northern parts of Summit and Riverton Townships. It ranges in relief from hilly with steep slopes to gently rolling or undulating. Other morainic areas occur in the northern part of Victory Township, the southwestern part of Free Soil Township, north of Fountain, east of Round Lake, in the southern part of Logan Township, and in the central part of Eden Township.

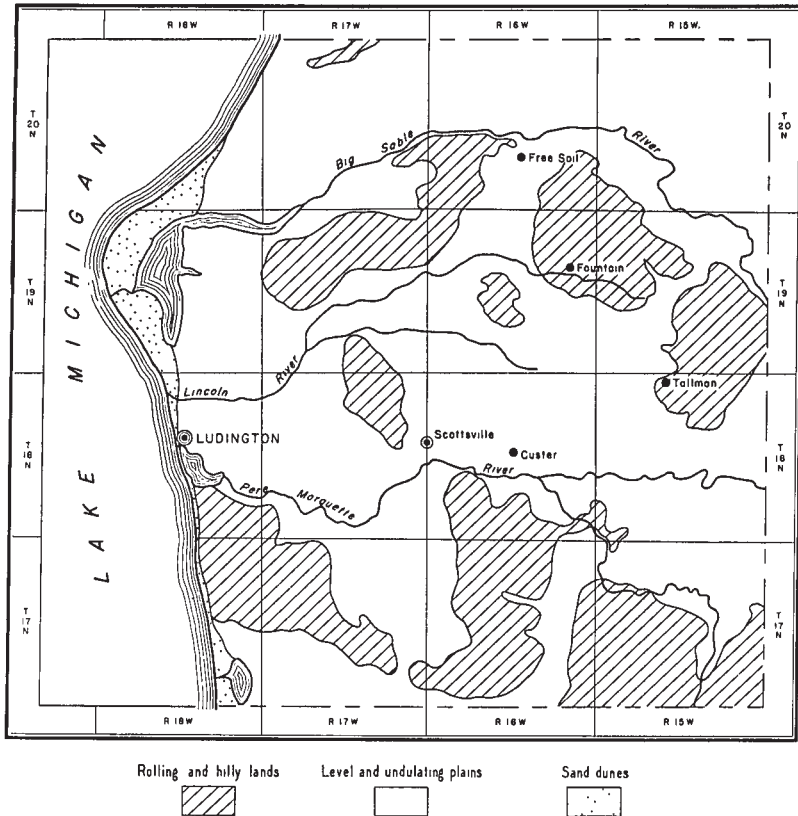


FIGURE 2.—Sketch map showing physiographic divisions of Mason County, Mich.

The main plain varies but little in elevation from one part of the county to another. It has characteristic features, in different places, of glacial outwash, lake-bed plain, terraced valleys, and level till plains.

Figure 2 shows the main physiographic divisions of this county. Stream dissection has wrought little change in the relief. Much of the county originally was covered with water during the highest lake stage of the glacial period. After the water receded, narrow but conspicuous sand ridges were built up above the plain by the action of wind. Most of these ridges range from 100 to 500 feet

in width and from 20 to 40 feet in height. In Meade Township an extensive area of outwash plain was also exposed to wind action, probably before being completely covered with vegetation, and as a result the eastern part of the township has a typical dune relief.

The rivers flow from east to west across the plain, paralleling the morainic areas, but in a few places they have cut through low extensions of the moraines. They flow into Lake Michigan. Moderately wide valleys have been cut by the largest streams. A few miles back from Lake Michigan, however, the streams and valleys become shallow and narrow, so that, with the exception of those along Pere Marquette River, the flood plains are only a few feet below the upland plains. The county is drained by Pere Marquette, Lincoln, Big Sable, Little Manistee, and Pentwater Rivers. The headwaters of Pentwater River are in the south-central part of the county, and Little Manistee River crosses the northeastern two sections. These streams have but few branches or tributaries, but where they do occur, they are sharply incised in the upland for short distances back from the main stream. Large areas are nearly flat and are still untouched by natural drainageways.

The plain areas of the county range in elevation from 642 feet to 698 feet above sea level. The vicinity of Bass Lake is 642 feet, Scottville 678 feet, Custer 698 feet, and the vicinity of Free Soil 676 feet. At one point along United States Highway No. 31, in the moraine in Riverton and Summit Townships, the elevation is 752 feet above sea level, and some points in the same moraine undoubtedly are higher (?).¹ The mean level of Lake Michigan (1936) is 578 feet above sea level.² The city of Ludington is 637 feet above sea level, or 59 feet above the lake level.³

The county originally was forested, with the exception of a few open marshes and a few scattered areas in the dry sand plain northwest of Free Soil. Originally, four general types of vegetation grew on the well-drained soils: (1) An association of white pine and red pine, with possibly a few oaks and shrubs. The pine did not reproduce extensively after lumbering and burning, and the land has now grown up to oaks, poplar, and red maple, with a ground cover of sweetfern and grasses. (2) A hardwood forest of sugar maple, beech, yellow birch, and hemlock as dominant trees, nearly virgin stands of which remain. In some places, after the forest has been cut-over, the second growth is similar to the original, and in other places it includes red maple, white birch, and poplar as the dominant species. (3) An open and sparse stand of jack pine and oaks, with a ground cover of native grasses and low shrubs. As this cover is of little or no commercial value, it has been but little disturbed. (4) A mixed forest of white pine, yellow birch, elm, ash, hemlock, and red maple. This has been largely cut-over, and the second growth consists mainly of poplar.

Four general types of vegetation grew on the poorly drained soils—(1) a white pine forest which has been cut-over and has grown up to poplar, birch, briers, willow, and other swamp shrubs and bushes;

¹ Italic numbers in parentheses refer to Literature Cited, p. 66.

² Michigan Geological Survey Division.

³ U. S. Weather Bureau data for Ludington, Mich.

(2) elm, ash, red maple, and aspen as dominant species; (3) dense stands of tamarack, arborvitae (white cedar), and black spruce; and (4) marsh grass, sedges, rushes, and cattail, together with low bushes.

The first permanent settlement of white people was made in Mason County about 1847, but settlement was slow until after 1855, when the county was organized. In 1855, 41 votes were cast at the election, and in 1880, 2,114 votes were cast. In 1864 the county population was 846, and in 1870 it had increased to 3,263. The 1930 United States census reports the population of the county as 18,756, of which 8,898 are classed as urban and 9,858 as rural. The density of population is given as 20 persons a square mile. The settlers came from the New England States, New York, Pennsylvania, Ohio, and southern Michigan. They were both native-born and foreign-born whites, many of them natives of Germany, Poland, Norway, and other European countries. Ludington, the county seat, has always been the largest center of population. It includes the entire urban population. The rural population is fairly evenly distributed, except in Grant, and northern parts of Free Soil, Meade, Sheridan, Branch, and Logan Townships, which are sparsely populated and contain fairly extensive uninhabited areas (6).

Scottville, the second town in size, with 1,002 inhabitants, is situated in the center of the better farming section. Custer, Fountain, and Free Soil are smaller towns on railroads in farming communities, and serve as shipping points and as places where food and clothing staples may be purchased. Railroad transportation is provided by the Pere Marquette Railway which crosses the county from west to east and by a branch of that railroad which runs to Manistee. The county is traversed from north to south by United States Highway No. 31, which is paved throughout its entire length in the State, and from east to west by United States Highway No. 10 which connects it with the large cities in the eastern and central parts of the State. Ludington has an excellent lake harbor and has daily year-round car-ferry service to both Milwaukee and Manitowoc, Wis.

A large quantity of the farm produce grown is consumed within the county. The products sold for outside consumption, largely fruits and vegetables, are shipped from the county by truck, railroad, and steamboat to the larger cities of Michigan, Ohio, Wisconsin, Indiana, and Illinois. Large quantities of milk, cream, string beans, cucumbers, and apples, and smaller quantities of wheat are processed for consumption within the county, chiefly at Scottville, where a cheese factory, a canning factory, a cider-vinegar factory, a creamery where butter is made, a pickle factory where cucumbers are processed, and a flour mill are located. Other farm products are sold to various marketing agencies in Scottville and Ludington, where large quantities of fruits are graded and shipped to large population centers for consumption. Considerable quantities of fruits and vegetables (principally potatoes) are sold at the farm to truckers who haul the products to large city markets. A few farmers haul their own produce to large cities or distant markets.

A good system of public roads reaches the important population centers. The main roads, which extend to all parts of the county,

are graded and graveled and are passable the year around, except during short periods in the winter when they are blocked by snow. The roads are being improved constantly, and new roads are being constructed to the unsettled sections. Public schools are conveniently located, and in few places is it necessary for children to go as far as 2 miles to attend grade school. Most of the schools in the rural sections are one- or two-room eight-grade schools. Larger 12-grade schools are located in most of the towns. Numerous churches of different denominations are scattered over the county, and several are in each town. Telephone lines reach all the settled areas, and many farms, especially along the main roads, have public-utilities power service. In 1929, according to the 1930 census, 232 farmhouses were lighted by electricity. Radios are fairly common on the farms. Most of the nonagricultural industries are carried on in Ludington. They include salt, shoe, watchcase, game-board, basket and crate, cabinet, clothing, and other factories.

CLIMATE

The climate is continental, modified by westerly winds across Lake Michigan. The winters are long, the summers short and warm.

The difference between the mean summer and winter temperatures is 39.3°. The ground usually is frozen and covered with snow during the winter. The rainfall is evenly distributed throughout the year, and during the growing season, the rainfall normally is ample for the production of the crops commonly grown. Sometimes, dry periods during the growing season cause crops to suffer from lack of moisture. Excessively wet weather during the spring and fall is only occasional.

The moderating effect of Lake Michigan on the climate of the western part of the county is very marked. Although no weather data are available which apply especially to the eastern part, it is generally recognized that the frost-free period is from 20 to 30 days shorter 10 or 20 miles inland from the lake. The breezes from the lake influence the temperatures so that winter temperatures normally are not so low or summer temperatures so high as they are farther east in the State or across the lake in Wisconsin. Cool lake breezes tend to retard plant growth in the spring until much of the danger of frost is past. As a result of optimum frost-free conditions, the southwestern part of the county has been developed into a specialized fruit-producing section.

The average date of the latest killing frost at Ludington, which is situated on the lake, is May 4, and the average date of the earliest killing frost is October 22, making an average frost-free season of 171 days. The latest killing frost on record occurred on June 17 and the earliest on September 4.

Table 1, compiled from the records of the United States Weather Bureau station at Ludington, gives the principal data concerning the climate of that part of the county near Lake Michigan.

TABLE 1.—*Normal monthly, seasonal, and annual temperature and precipitation at Ludington, Mason County, Mich.*

[Elevation 637 feet]

Month	Temperature			Precipitation			
	Mean	Absolute maximum	Absolute minimum	Mean	Total amount for the driest year (1901)	Total amount for the wettest year (1912)	Snow, average depth
	° F.	° F.	° F.	Inches	Inches	Inches	Inches
December.....	28.4	58	-5	2.48	1.90	1.54	16.5
January.....	23.1	58	-12	2.13	1.46	2.60	17.4
February.....	22.5	65	-37	2.02	1.05	1.55	12.4
Winter.....	24.7	65	-37	6.63	4.41	5.69	46.3
March.....	30.1	72	-5	2.29	2.25	.40	7.8
April.....	41.9	83	10	2.54	.40	68	1.7
May.....	52.2	86	24	3.02	.76	11.59	.2
Spring.....	41.4	86	-5	7.85	3.41	12.67	9.7
June.....	60.5	95	29	2.91	.56	1.06	.0
July.....	66.2	98	40	3.04	1.97	11.68	.0
August.....	65.3	91	38	2.63	.75	4.32	.0
Summer.....	64.0	98	29	8.58	3.28	17.06	.0
September.....	59.3	88	24	3.25	1.16	4.50	.0
October.....	49.7	79	20	2.92	1.93	3.01	2.4
November.....	37.4	76	9	2.68	.79	2.74	5.2
Fall.....	48.8	88	9	8.85	3.88	10.25	7.6
Year.....	44.7	98	-37	31.91	14.98	45.67	63.6

These data on climate cannot be taken as an average for the entire county, because at as short a distance as 5 miles inland from the lake the temperature conditions are different, and the length of the frost-free period varies considerably over the county, depending both on air drainage and elevation as well as distance from the lake. In some localities in the eastern part, frosts may occur during any month of the year.

The frost-free dates as given by the United States Weather Bureau station at Hart, Mich., the county seat of Oceana County, 24 miles southeast of Ludington, might be considered a better average for Mason County than the average frost-free dates given by the Ludington station. Hart is located 7 miles from Lake Michigan at an elevation of 655 feet above sea level. The average frost-free period for this station is 144 days, or from May 16 to October 7, but killing frosts have occurred as late as June 23 and as early as September 2.

Severely damaging winds and storms are uncommon as are also severe electrical storms. Hard, beating, and severely eroding rains are uncommon. Floods are unknown, and the only extreme variations in stream levels are caused by melting snow and ice in the spring.

AGRICULTURAL HISTORY AND STATISTICS

Mason County was organized in 1855, although the first permanent settlement in this area had been made in 1847. The first agricultural

activity was the raising of a few staple crops, chiefly corn and potatoes, for home consumption, and the rest of the year was spent clearing land and working in lumber camps and mills. As more land was cleared and local markets became better for grain and fruits, a greater acreage was devoted to orchards, beans, wheat, and corn. When difficulty was experienced in maintaining yields, more attention was given to livestock and the use of commercial fertilizers, and the increase in the numbers of livestock and the value of livestock products has been constant. The agricultural development of the county is shown to some extent by the census data set forth in table 2.

TABLE 2.—*Rural population; number, size, and value of farms; and tenure of farms in Mason County, Mich., in stated years*

Year	Rural population	Farms	Land in farms	Average size of farms	Average value of all property per farm	Assessed acre value of farm land	Farms operated by—		
							Own-ers	Ten-ants	Man-agers
		Number	Percent	Acres	Dollars	Dollars	Percent	Percent	Percent
1864 ¹	846	776							
1870 ¹	3,260	4,374							
1874 ¹	5,361	6,444							
1880	5,875	709	20.8	86.0	1,669	16.57	93.6	6.4	
1890	8,808	1,271	27.6	69.0	2,134	25.84	89.9	10.1	
1900	11,719	1,885	41.5	69.6	2,212	19.05	91.1	7.4	1.5
1910	12,700	2,124	54.2	80.6	4,273	30.08	91.1	8.1	.8
1920	11,021	2,011	58.0	91.2	6,132	35.42	87.1	11.4	1.5
1930	9,858	1,637	49.1	94.8	6,405	52.40	88.1	10.8	1.1
1935	7,624	1,807	55.6	97.3		39.21	86.3	13.4	.3

¹ Data from a history of Manistee, Mason, and Oceana Counties, Mich. (6).

² Total population.

³ Acres improved land.

⁴ Includes buildings.

⁵ Farm population.

In 1873, 648 acres of corn yielded 19,723 bushels, and 503 acres of orchard, including peach, apple, pear, plum, and cherry trees, and 3,673 bushels of apples, were reported. In 1874, 44,199 bushels of potatoes, 2,142 tons of hay, 4,150 pounds of pork, and 35,306 pounds of butter were reported produced in the county.

In 1909, only 89 farmers used commercial fertilizers valued at \$2,489, but in 1929, 541 farmers used commercial fertilizers valued at \$31,031. The fertilizer used is largely a ready-mixed high-grade carrier containing 16 percent or more of available plant nutrients. The lime used is chiefly in the form of marl or waste from the Manistee paper mills. Both lime and fertilizer are efficient in counteracting soil acidity.

The laborers on the farms are, for the most part, resident whites who work either by the day, month, or year. The hire of labor was reported by 799 farmers in 1929 at a total cost of \$196,616, or \$246.08 a farm reporting. Labor to harvest special crops, as vegetables and fruits, is furnished to some extent by school children from the towns and villages and partly by transient labor that moves into the area in anticipation of the demand for fruit pickers.

The farms range in size from small specialized fruit farms and other small farms, used as a place of residence and to supplement

a small salary income, to those of 300 to 600 acres. The average size of farms is shown in table 2, which also shows the trend toward larger farms. This movement toward larger farms is probably due, to some extent, to an attempt to cut unit production costs, by increasing the land acreage per man and machinery unit.

Both share and cash systems of rental are used, depending to some extent on the individual and whether he is an owner operator renting additional land for more economical use of his time and machinery, or whether he is a land renter with limited capital.

Table 3 gives the total acreages of various crops as reported by the United States census reports from 1880 to 1935, showing the trend in crops and acreages.

TABLE 3.—*Acreages of the principal crops in Mason County, Mich., in stated years*

Crop	1870	1889	1899	1909	1919	1929	1934
	<i>Acres</i>	<i>Acres</i>	<i>Acres</i>	<i>Acres</i>	<i>Acres</i>	<i>Acres</i>	<i>Acres</i>
Corn for grain.....	1,603	2,507	9,736	10,179	8,433	3,009	5,467
Oats.....	936	3,307	2,422	8,152	11,391	8,219	7,840
Wheat.....	3,092	3,007	11,560	8,679	11,184	3,237	4,353
Rye.....	339	1,511	2,767	3,411	6,886	2,674	2,702
Barley.....	244	56	105	88	604	1,222	295
Potatoes.....	1,250	1,797	3,632	5,684	4,517	3,625	3,765
Dry beans.....	—	—	70	1,004	2,075	3,581	4,120
Hay (all).....	3,097	10,637	15,459	22,555	24,289	26,722	27,157
Alfalfa.....	—	—	—	208	1,113	4,784	10,695
Timothy, and timothy and clover mixed.....	—	—	—	21,227	20,969	16,452	10,848
Clover.....	—	—	382	725	744	3,680	108
Other tame grasses.....	—	—	13,757	158	433	812	14,775
Wild grasses.....	—	—	210	115	340	842	—
Grains cut green.....	—	—	1,110	122	690	152	671
Strawberries.....	—	—	243	144	167	218	301
Raspberries.....	—	—	260	372	251	343	—
	<i>Trees</i>	<i>Trees</i>	<i>Trees</i>	<i>Trees</i>	<i>Trees</i>	<i>Trees</i>	<i>Trees</i>
Apples.....	61,710	150,629	126,548	125,917	114,080	125,513	125,513
Peaches.....	24,524	295,731	203,502	113,425	39,296	32,011	32,011
Pears.....	2,567	15,151	9,112	14,111	18,765	21,760	21,760
Plums.....	8,623	22,057	14,636	15,220	12,535	12,772	12,772
Cherries.....	2,966	13,043	20,490	28,126	36,539	67,751	67,751

¹ Includes wild grasses.

Table 4 gives the value of agricultural products by classes in this county in 1929 as reported by the United States census.

TABLE 4.—*Value of agricultural and livestock products by classes in Mason County, Mich., in 1929*

Crop	Value	Livestock products	Value
Cereals.....	\$269,099	Dairy products.....	\$702,976
Other grains and seeds.....	123,020	Wool.....	3,708
Hay and forage.....	471,481	Poultry and eggs.....	278,337
Vegetables (potatoes included).....	300,356	Honey.....	3,926
Fruits and nuts.....	500,055	Total.....	988,947
Other crops.....	7,303		
Forest products.....	53,055		
Total.....	1,724,369		

The 1930 Federal census reports 1,386 automobiles on farms, 406 motortrucks, 224 tractors, 486 farm homes with telephone service, 799 farm homes with water piped to the house, 232 farm homes lighted by

electricity, 122 farms on concrete roads, 6 on macadam roads, 1,025 on graveled roads, 156 on improved dirt roads, 277 on unimproved dirt roads, and 51 unreported.

In 1929, Mason County ranked sixth among the counties of the State in production of apples, eighth in production of cherries, eighth in production of peaches, and third in production of pears.

On April 1, 1935, the livestock on the farms included the following: Cattle, 14,509; horses, 3,402; sheep, 1,448; swine, 3,011; and chickens, 72,202.

SOIL-SURVEY METHODS AND DEFINITIONS

Soil surveying consists of the examination, classification, and mapping of soils in the field.

The soils are examined systematically in many locations. Test pits are dug, borings are made, and exposures, such as those in road or railroad cuts, are studied. Each excavation exposes a series of distinct soil layers or horizons called, collectively, the soil profile. Each horizon of the soil, as well as the parent material beneath the soil, is studied in detail; and the color, structure, porosity, consistence, texture, and content of organic matter, roots, gravel, and stone are noted. The reaction of the soil⁴ and its content of lime and salts are determined by simple tests.⁵ The drainage, both internal and external, and other external features, such as the relief, or lay of the land, are taken into consideration, and the interrelation of soils and vegetation is studied.

The soils are classified according to their characteristics, both internal and external, special emphasis being given to those features influencing the adaptation of the land for the growing of crop plants, grasses, and trees. On the basis of these characteristics, soils are grouped into classification units. The three principal units are: (1) Series, (2) type, and (3) phase. Some areas of land, such as coastal beach or bare rocky mountainsides, have no true soil, and these are called (4) miscellaneous land types.

The most important of these groups is the series, which includes soils having the same genetic horizons, similar in their important characteristics and arrangement in the soil profile and developed from a particular type of parent material. Thus, the series includes soils having essentially the same color, structure, and other important internal characteristics, and the same natural drainage conditions and range in relief. The texture of the upper part of the soil, including that commonly plowed, may differ within a series. The soil series are given names of places or geographic features near which they were first mapped. Thus, Emmet, Kalkaska, and Miami are names of important soil series in Michigan.

Within a soil series are one or more soil types, defined according to the texture of the upper part of the soil. Thus, the class name of the soil texture, such as sand, loamy sand, sandy loam, loam, silt loam, clay loam, silty clay loam, or clay, is added to the series name to give

⁴The reaction of the soil is its degree of acidity or alkalinity. It may be expressed mathematically as the pH value. A pH value of 7 indicates precise neutrality, higher values indicate alkalinity, and lower values indicate acidity.

⁵The total content of readily soluble salts is determined by the use of the electrolytic bridge. Phenolphthalein solution is used to detect a strong alkaline reaction.

the complete name of the soil type. For example, Emmet sandy loam and Emmet loamy sand are soil types within the Emmet series. Except for the texture of the surface soil, these soil types have approximately the same internal and external characteristics. The soil type is the unit of mapping and because of its specific character is usually the soil unit to which agronomic data are definitely related.

A phase of a soil type is recognized for the separation of soils within a type which differ in some minor soil characteristic, but which may, nevertheless, have an important practical significance. Differences in relief, stoniness, and the degree of accelerated erosion are frequently shown as phases. Thus, within the normal range of relief for a soil type, some parts may be adapted to the use of machinery and the growth of cultivated crops and other parts are not so adapted. Even though no important differences may exist in the soil itself or in its capability for the growth of native vegetation throughout the range in relief, there may be important differences in respect to the growth of cultivated plants. In such soils the more sloping parts of the soil type may be segregated on the map as a sloping or a hilly phase. Similarly, soils having differences in stoniness may be mapped as phases, even though these differences are not reflected in the character of the soil or in the growth of native plants.

The soil map of Mason County was prepared on a base map made by the United States Geological Survey. Aerial mosaics compiled from aerial photographs taken by the Air Corps of the United States Army also were used in the soil mapping. Differences in vegetation, as well as in soil color, show on the aerial photographs, and it was possible to locate and plot certain soil boundaries on the mosaics. For example, it was possible to accurately locate swamp areas scattered about in larger areas of the timbered soil types.

The soil map of the county shows townships and sections. Dividing a section into quarters divides the section into 160-acre tracts. The names of the civil townships are printed on each township on the map, and the township and range numbers of the Land Office surveys are placed around the margin of the map. Each Land Office section carries its number on the map.

SOILS AND CROPS ^a

The soils of Mason County range from dry sands of the lake dunes to dark-colored poorly drained silt loams, mucks, and peats. Over the greater part of the county, the association of areas of soils of different textures and colors is complex and the areas are of irregular shapes. The larger areas of soils that are fairly uniform in texture, color, drainage, and relief throughout their extent are, for the most part, very sandy soils unsuited to present-day agriculture.

Sands and loamy sands predominate in total area, occupying about 58 percent of the land surface of the county; organic soils occupy

^a Large areas of Plainfield sand in Manistee County join areas of Grayling sand in Mason County, because, when Manistee County was surveyed in 1922, the Grayling soils had not been differentiated from the Plainfield soils. These soils are similar in many features, particularly composition of material which is largely quartz sand. Both are essentially dry sandy soils on broad outwash plains and stream terraces. In Michigan, the Plainfield soils are confined to the southern part of the Lower Peninsula; the Grayling soils are associated with the Podzol soils of the Upper Peninsula and the northern part of the Lower Peninsula.

about 9 percent; and the remaining 33 percent is divided among sandy loams, loams, and silt loams, which are the important agricultural soils.

The agriculture of the county, as a whole, is rather diversified, with some diversity in crops and source of income on all farms. Four general types of farms, based on source of income or types of crops grown, are as follows: (1) Farms on which the chief source of income is from tree fruits—apples, pears, cherries, and peaches; (2) farms depending chiefly on grains, hay, and potatoes for income; (3) those depending chiefly on dairy cattle for income; and (4) small subsistence farms, mainly of sandy soils, including a few acres of various crops, from one to four cows for subsistence purposes, and generally a few acres of beans or cucumbers for a small cash income. Most of the fruit farmers supplement their income either with dairy products, beef cattle, small grains, beans, or potatoes; many grain, bean, and potato farmers raise some dairy or beef cattle; and most dairy farmers grow small grains and beans to some extent for additional income.

As a rule, the meat, fruit, vegetables, butter, eggs, and cereals are produced for home consumption on the individual farms. On most farms, there are small orchards and gardens producing vegetables and small fruits. It is uncommon to find a farm without one or more milk-producing cows and a small flock of chickens, and on some farms both chickens and dairy cattle are kept to provide a cash income. The crops and the proportion of land in each crop in different parts of the county are determined largely by differences in the soil, especially where these differences are associated with differences in topographic position. Other influencing factors, especially in regard to fruit culture, are elevation above Lake Michigan, distance from the lake, distance from market, and personal choice as to crops. A combination of these factors is largely responsible for the fact that about 30 or 35 square miles of land in Summit and Riverton Townships produce enough fruit to give Mason County sixth place among the counties of the State in the production of tree fruits (pl. 1, A). The location near Lake Michigan is an important factor in the value of fruit land, but the soil characteristics also are governing factors in its selection.

Large areas of land within the county are climatically suited to the production of fruit and other crops; but, owing to the unfavorable characteristics of the soils, no attempt has been made to farm them. Thus, even near Lake Michigan, the character of the soil is an important factor in determining land use, with economic and social factors entering in to some extent. The production of grains, hay, potatoes, and beans as cash crops is determined largely by soil conditions. Heavy-textured soils, such as loams and silt loams, are considered too heavy for potatoes but ideal for grains and hay. Low poorly drained soils are too subject to frost for consistent production of beans, potatoes, and corn, but they have extensive use for forage and pasture.

Most of the soils of this county are low in organic matter, and the best known method of building up the organic-matter supply and the productiveness of the soil is by liberal applications of barnyard manure. Suitable forage for livestock can be grown on most of

the soils under cultivation, and, owing to the demand for dairy and other livestock products, together with the need for the manure on the farms, livestock farming is practical.

Owing to their loose open structure, poor moisture-holding capacity, and lack of essential plant nutrients, large areas of sand and loamy sand soils are unsuited to agriculture and have never been cleared, although they have been lumbered or cut-over and in some places are now pastured. Some areas, owing to steepness of slope and the difficulty of cultivation, likewise are used for pasture or are left as forest or waste land. The fourth type of farming, the subsistence type, generally is carried on on soils inherently unsuited to profitable commercial agriculture.

For discussion and description the soils and land types are placed in four groups, based on natural soil conditions, as follows: (1) Well-drained soils, subdivided into (a) sandy loams, loams, and silt loams and (b) sands and loamy sands; (2) imperfectly drained soils, subdivided into (a) sandy loams and (b) sands and loamy sands; (3) poorly drained soils, subdivided into (a) mineral soils and (b) organic soils; and (4) miscellaneous land types. Group 1 includes soils that are naturally well drained and have developed under conditions of good drainage. The soils of this group include the best and most valuable soils of the county as well as the poorest and least valuable soils, so it becomes necessary, in order to bring out differences in land use, to recognize subgroups. Subgroup a, or the sandy loams, loams, and silt loams, includes the most important agricultural soils, both because of the area under cultivation and the value of agricultural products. The soils of subgroup b, the sands and loamy sands, cover more than one-half of the county, but most of them are comparatively poor, have not been cleared, and are most valuable for use as forest and pasture land.

The soils of group 2 are imperfectly drained soils developed under a slightly higher water table than are the well-drained soils. Some of these soils are sufficiently well drained under natural conditions for the production of all crops except tree fruits, but others require some artificial drainage for practical agricultural use. The soils of subgroup a, the sandy loams, are fairly valuable agricultural soils, generally closely associated with the better grade of well-drained soils. The soils of subgroup b, the imperfectly drained sands and loamy sands, are soils that, for the most part, are better adapted to forestry and pasture than to general farm crops and fruits. The soils of group 3, the poorly drained soils, have had the water table near or over the surface during their development. They all require artificial drainage in order to grow farm crops, and all are unsuited to tree fruits. Small fruits, such as strawberries and raspberries, do well on some soils of this group. Subgroup a consists of mineral soils that are poorly drained, most of which may be used for the production of hay, grains, or pasture, or at present are in wild woodland. Subgroup b includes the mucks and peats, which are, for the most part, wild or uncleared land or unimproved pasture land. Such land, owing to cost of artificial drainage and control of the water table, combined with its natural susceptibility to frost, is utilized to a very small extent for cultivated crops. Group 4 includes four types of miscellaneous materials that have no agricultural value.

In the following pages, the soils of Mason County are described in detail, and their agricultural relationships are discussed; their distribution and location are shown on the accompanying soil map; and their acreage and proportionate extent are given in table 5.

TABLE 5.—*Acreage and proportionate extent of the soils mapped in Mason County, Mich.*

Soil type	Acres	Per- cent	Soil type	Acres	Per- cent
Nester loam.....	17,792	5.6	Bridgman fine sand.....	4,672	1.5
Nester loam, rolling phase.....	3,520	1.1	Dune sand.....	3,456	1.1
Nester loam, steep phase.....	1,792	.6	Ogemaw sandy loam.....	14,528	4.6
Kent silt loam.....	896	.3	Iosco sandy loam.....	8,896	2.8
Selkirk silt loam.....	12,224	3.9	Ottawa fine sandy loam.....	320	.1
Mancelona sandy loam.....	448	.1	Arenac fine sandy loam.....	2,368	.7
Antrim sandy loam.....	1,152	.4	Arenac loamy sand.....	6,464	2.0
Emmet sandy loam.....	7,296	2.3	Arenac loamy sand, rolling phase.....	512	.2
Emmet sandy loam, smooth phase.....	6,336	2.0	Ottawa loamy fine sand.....	640	.2
Emmet sandy loam, steep phase.....	2,176	.7	Ottawa loamy fine sand, broken phase.....	832	.3
Montcalm sandy loam.....	2,496	.8	Saugatuck sand.....	20,608	6.5
Montcalm sandy loam, steep phase.....	1,088	.3	Bergland loam.....	3,712	1.2
Emmet loamy sand.....	2,816	.9	Otto sandy loam.....	768	.2
Emmet loamy sand, smooth phase.....	2,432	.8	Otto silt loam.....	1,792	.6
Emmet loamy sand, steep phase.....	1,728	.5	Munuscong sandy loam.....	4,416	1.4
Weare fine sand.....	7,168	2.3	Granby sandy loam.....	2,368	.7
Echo loamy sand.....	384	.1	Newton loamy sand.....	11,520	3.6
Kalkaska loamy sand.....	14,080	4.4	Griffin sandy loam.....	9,024	2.9
Kalkaska loamy sand, slope phase.....	1,280	.4	Maumee loam.....	192	.1
Roselawn loamy sand.....	22,720	7.2	Walkkill loam.....	384	.1
Roselawn loamy sand, smooth phase.....	4,992	1.6	Lupton muck.....	11,136	3.5
Rubicon sand.....	35,008	11.1	Houghton muck.....	2,304	.7
Rubicon sand, slope phase.....	3,072	1.0	Rifle peat.....	6,592	2.1
Rubicon fine sand.....	256	.1	Burned muck over clay.....	64	(¹)
Grayling sand.....	26,176	8.3	Greenwood peat.....	1,664	.5
Grayling sand, slope phase.....	4,480	1.4	Burned muck over sand.....	1,536	.5
Wallace fine sand.....	3,648	1.2	Kerston muck.....	5,312	1.7
Saugatuck sand, drained phase.....	320	.1	Coastal beach.....	576	.2
Newton loamy sand, drained phase.....	1,280	.4	Lake bluff.....	128	(¹)
			Made land.....	192	.1
			Gravel pits.....	128	(¹)
			Total.....	316,160	-----

¹ Less than 0.1 percent.

WELL-DRAINED SOILS

SANDY LOAMS, LOAMS, AND SILT LOAMS

Nester loam.—Nester loam is the most valuable agricultural soil in the county, as it is higher in natural fertility and more retentive of fertility than any other well-drained soil. The 6- or 8-inch plow soil consists of grayish-brown or brownish-gray loam containing a moderate quantity of organic matter. The material in this layer ranges from medium to strongly acid, but it is friable and fairly easily worked. It contains a few stones and, here and there, a boulder, but in few places are these sufficiently numerous to handicap cultivation greatly. The subsoil consists of a 10- to 14-inch layer of reddish-brown heavy sandy clay or clay, which is medium acid. It is plastic and sticky when wet but crumbles readily into small angular lumps when dry. The lumps have a thin coating of dark-brown material, but the insides of them are light reddish brown. The substratum, at a depth ranging from 24 to 36 inches, is brownish-yellow or light-brown sandy till clay or heavy sandy clay with a pink cast. This material is calcareous or has an ample supply of lime for the growth of crops. The roots of plants and trees readily penetrate

all layers of this soil, and the roots of alfalfa, after one or two seasons' growth, extend into the limy layer.

Iosco sandy loam is closely associated with Nester loam, and small areas of Iosco sandy loam and other areas having from 1 to 2 feet of sandy loam material over heavy clay are included in areas mapped as Nester loam. Small areas, less than one acre in size, of poorly drained Bergland and Munuscong soils also are included. In a few places, as much as 30 percent of the surface soil of an area mapped as Nester loam may be sandy loam, but in general, the areas mapped as Nester loam have a fairly heavy surface soil ranging from 6 to 18 inches in thickness.

The principal areas of Nester loam are in Victory, Sherman, Amber, Custer, Riverton, Eden, and Logan Townships, and small areas are elsewhere in the county. A total area of 27.8 square miles is mapped. The relief ranges from undulating to gently sloping with a maximum grade not exceeding 7 percent. The slope of the land is sufficiently gentle that all kinds of farm machinery can be used with ease. The drainage of this soil, both internal and external, is good, and artificial drainage is not necessary for the production of the crops commonly grown on it.

More than 90 percent of this land has been cleared or cut-over, but originally it was forested with a good stand of sugar maple, beech, elm, white ash, hemlock, ironwood, basswood, and a few oaks and white pine.

Two general types of farming are carried on on Nester loam and the soils associated with it—one consisting of general farming and dairying; the other, chiefly where Nester loam is associated with the Emmet soils, consisting of fruit growing and dairy farming. Crop yields are generally good, acre yields of corn ranging from 25 to 40 bushels; potatoes, from 100 to 200 bushels; beans, from 5 to 15 bushels; wheat, from 20 to 40 bushels; oats, from 30 to 60 bushels; rye, from 15 to 25 bushels; and alfalfa, from 3 to 4 tons. This soil is considered too heavy for best results from potatoes, but some good yields are obtained under careful management. Green manure, such as sweetclover, frequently is plowed under, in order to loosen the structure of the surface soil and increase the organic-matter content. Good response from crops is obtained from the use of both barnyard manure and commercial fertilizer.

It is a common practice to use a 3- to 5-year rotation and apply commercial fertilizer, usually superphosphate, in quantities ranging from 100 to 200 pounds an acre for wheat, and to apply stable manure or provide a green-manure crop to be plowed under for corn. Small quantities of commercial fertilizers are now being used on land for beans, corn, and potatoes. Acre applications ranging from 100 to 200 pounds of 0-20-20¹ are sometimes used with 1 to 5 tons of lime for alfalfa, although good stands of alfalfa are obtained without liming on uniform areas of Nester loam. The areas of sandy variations, that are more acid than typical Nester loam, make liming necessary. Care must be exercised not to work this soil when too wet, as it will become cloddy and hard when dry. This soil has a tendency to crust in cultivated fields after rains, and the crust re-

¹ Percentages, respectively, of nitrogen, phosphoric acid, and potash.

quires breaking by cultivation, in order to prevent excessive loss of moisture.

Apples and pears are better adapted to this soil than are any other tree fruits, though cherries also do well, but fruit farming on Nester loam is chiefly on farms where a part of the land consists of Emmet soils and where air drainage is good.

Nester loam, rolling phase.—Nester loam, rolling phase, is essentially the same as typical Nester loam, except in slight differences related to a stronger relief. The relief ranges from sloping to gently rolling or billowy, with rounded hills and uniform slopes ranging from an 8 to 15 percent gradient. On such slopes, erosion is not serious, and the land can be farmed with tractors and labor-saving machinery, but with greater difficulty than on typical Nester loam. A few gullies have been washed in some areas, but sheet erosion is more noticeable, as it has removed the plow soil in numerous spots on slopes, thereby exposing the underlying red clay and further increasing the difficulty of working this land. Reasonably careful management is necessary in order to prevent gullyng on this soil which occupies the more strongly sloping land in association with Nester loam, especially in Riverton and Eden Townships.

This soil is cropped in much the same manner as is typical Nester loam. There is, however, a larger acreage in fruit and alfalfa. Alfalfa makes good growth on eroded slopes without the addition of lime. Yields of all crops are practically the same or slightly less than on typical Nester loam, with a slightly higher cost of production owing to the steeper slope.

Nester loam, steep phase.—The steep phase of Nester loam is closely associated with typical Nester loam, generally along streams where the slopes are too steep for the use of tractors, binders, hay loaders, and other commonly used labor-saving machinery. In most places the land is so steep that it is difficult to cultivate, even with horse-drawn implements. This soil is not extensive. It is mapped chiefly in Riverton, Eden, and Victory Townships. About one-half of the land has been cleared, and at present is used almost entirely for pasture and hay. Alfalfa does well on most of these steep slopes, as the plow soil consists largely of reddish-brown clay loam, which is slightly acid or neutral, with alkaline clay 8 or 10 inches beneath the surface. This land is too steep for economical agricultural production but, where handled carefully, provides fair or good pasture.

Kent silt loam.—Kent silt loam has a grayish-brown or dark-gray finely granular heavy silt loam plow soil, from 4 to 8 inches thick, which is medium to strongly acid. This is underlain by reddish-brown or yellowish-brown clay, which is 6 or 8 inches thick, is strongly acid, and is streaked with seams filled with light-gray sandy loam. Under virgin conditions the surface soil consists of a 1- or 2-inch organic layer, composed of nearly black decomposed and disintegrated leaves and woody material, underlain by a thin leached layer of very light gray fine sandy loam or silt loam, overlying reddish-brown or yellowish-brown clay, with numerous tongues or streaks of the light-colored material extending from 6 to 8 inches into the clay. At a depth ranging from 10 to 20 inches, the material is dark yellowish-red heavy clay or silty clay, that is very plastic when wet but readily breaks or crumbles when dry into

small blocks or cubes ranging from one-fourth to one-half inch in diameter. The material in this layer is medium acid. At a depth ranging from 24 to 30 inches, the material grades into light yellowish-red heavy clay which is high in lime and contains numerous light-gray streaks and a few rust-brown mottlings.

In places, small areas of Ogemaw sandy loam, Bergland loam, and Munuscong sandy loam are included with mapped areas of Kent silt loam. As a whole, Kent silt loam has a uniform silt loam or loam surface soil over heavy silty clay.

The principal areas of Kent silt loam are in sec. 29, Amber Township, and secs. 34 and 36, Riverton Township. Its total area is small.

The relief ranges from undulating to gently sloping, with no slopes sufficiently steep to prevent the use of labor-saving machinery. This soil occupies high smooth heavy-textured till plains or old lake-bed plains. Natural drainage is slow, both surface and internal, but it is sufficient for the growth of all general crops without artificial drainage. Nearly all of Kent silt loam in this county has been cleared, but it originally supported dense forests consisting largely of sugar maple, beech, and hemlock.

Small grains, corn, beans, and alfalfa hay are the chief crops grown, with hay occupying the largest acreage. Acre yields of corn range from 20 to 35 bushels, wheat 20 to 40 bushels, oats 20 to 50 bushels, beans 5 to 15 bushels, and alfalfa 2 to 4 tons. Sweetclover frequently is grown for pasture and for soil improvement, and occasionally for hay. In some places it is possible to obtain stands of alfalfa without the use of lime, but generally it is necessary to use large quantities of barnyard manure. All crops on the soil respond well to the use of commercial fertilizers, but in general the land for wheat receives most of the fertilizer used during the rotation. The most common acre application of fertilizer is from 100 to 200 pounds of superphosphate.

Selkirk silt loam.—Selkirk silt loam, agriculturally, is the most important and most extensive soil of the smooth nearly flat "clay" plains. It is extensively used as a hay and grain soil. The plow layer consists of fine-granular grayish-brown or dull-gray silt loam or heavy loam, which is acid in reaction. This soil is low in organic matter, and, although the supply is sufficient when the land is first plowed or cleared, it needs to be replenished at regular periods. The subsoil consists of a 12- to 20-inch layer of reddish-brown or reddish-yellow heavy plastic silty clay, slightly mottled with bright yellow and rust brown. It ranges from medium to slightly acid. When dry, the material readily crumbles to small blocks or cubes, ranging in diameter from $\frac{1}{2}$ to $1\frac{1}{2}$ inches, the sides of which are coated with dark-brown material. Below a depth of 24 inches is the substratum of yellowish-brown calcareous, or alkaline, silty clay. The structure of the upper part of this layer is blocky but, below a depth of 36 inches, is massive. Stones and boulders are absent or are so few that they do not interfere materially with cultivation. Roots, especially those of alfalfa, penetrate readily to layers high in lime content and permanently moist.

Two types of variations are included in areas mapped as Selkirk silt loam. One includes the low poorly drained spots of Bergland loam or Munuscong sandy loam which, because of their small size,

were not mapped separately; and the other includes areas having a sandy loam covering ranging from 1 to 3 feet in thickness over the heavy silty clay, that, because of their complex arrangement and mixture within areas of typical Selkirk silt loam, are not separated on the map. Some of the sandy loam areas have a coffee-brown hardpan or other hardpanlike layer of sand or sandy loam between the surface soil and the underlying heavy clay. Where areas of such soil are of sufficient size, they are mapped as Ogemaw sandy loam, described elsewhere in this report. In a few places, as much as 30 percent of an area mapped as Selkirk silt loam may have a sandy loam, fine sandy loam, or loam surface soil over a clay subsoil.

Selkirk silt loam occupies large areas in Riverton, Eden, Amber, and Custer Townships, as well as small areas scattered throughout the county. Its total area mapped is almost 20 square miles.

The relief ranges from nearly flat to undulating, with maximum slopes generally less than 3 percent. The land can be worked with tractors and other labor-saving machinery. This soil has developed on old lake plains or heavy-textured till plains where the material was laid down smoothly by ice and water during the glacial period. Both surface and internal drainage range from good to poor. Numerous associated and included low spots are poorly drained, although water seldom stands on such spots during the summer.

Originally this soil was forested with a dense stand of sugar maple, beech, elm, and hemlock, with a few white pine, ash, cherry, ironwood, and other trees. More than 90 percent of the land has been cleared and placed under cultivation. It is used chiefly for the growing of hay, grain, and corn, and for the raising of livestock. About 15 percent of the cultivated area is used for wheat, 10 percent for corn, 10 percent for oats, from 5 to 10 percent for beans, and the remainder largely for hay and pasture. Alfalfa hay yields from 2 to 3 tons an acre; wheat from 20 to 40 bushels, with occasional yields of 50 bushels reported; corn from 10 to 35 bushels; and oats from 20 to 50 bushels. Tilth conditions range widely in this soil, and it is very responsive to cultural methods and drainage improvements. Without increasing the speed of drainage or the organic-matter content, low yields are common; but by artificial drainage, the use of barnyard manure, fall plowing whenever possible, and the carrying on of tillage operations only when the moisture content is at the optimum, maximum yields can be obtained. Small applications of lime are needed in the growing of alfalfa. The included spots of sandy loam are more strongly acid than is the typical soil, and it is desirable to add slightly more lime and other soil amendments to these spots. Variations of either a 3- or 5-year crop rotation are commonly practiced, and some commercial fertilizers generally are used with wheat in the rotation, although corn and oats sometimes receive smaller applications. Superphosphate is the most effective fertilizer for this soil, both 0-16-0 and 0-20-0 being used, although applications of 0-20-20 are used by some farmers with alfalfa seedings. Artificial drainage is not very common, and what drainage is accomplished is by means of open ditches. Owing to the smooth relief, erosion is not an important problem. If plowed when too wet, the soil bakes or puddles, making it hard to work for several

years. In cultivated fields the soil bakes or forms a crust following rains, so that cultivation as soon as possible following rains is advisable in order to break up the crust and conserve moisture.

Mancelona sandy loam.—Mancelona sandy loam has a 5- or 6-inch dark-gray or dark grayish-brown plow soil which is acid in reaction. It is underlain by a 4- or 5-inch layer of dark-brown or yellowish-brown loamy sand or light sandy loam that is strongly acid. Below this is a 12- to 24-inch layer of yellow or brownish-yellow sand, medium acid in reaction, underlain by a 2- to 4-inch layer of reddish-brown light sandy clay which is strongly acid. Below the clay layer is coarse and medium sand and gravel containing numerous pockets of dry calcareous sand and gravel. The reaction of the material in the medium and coarse sand substrata generally is slightly acid to a depth ranging from 40 to 50 inches. The light sandy clay layer is absent in a few areas, and some included areas more closely resemble Kalkaska loamy sand. In many places some small gravel are scattered over the surface and through the soil.

The small total area of Mancelona sandy loam lies mainly in the south-central part of Summit Township. This soil occupies sandy and gravelly outwash plains with a smooth undulating relief. Natural drainage is good, in places excessive. The land originally was forested with hardwoods.

About 90 percent of this soil is cleared and under cultivation. Tree fruits and small fruits are grown, and some general farming and dairying are practiced. Potatoes, alfalfa, corn, oats, and beans return fair or small yields, depending on the management of the soil and the quantity of soil amendments used. During dry seasons crops suffer from lack of moisture. Mancelona sandy loam is agriculturally unimportant because of its small total area, but it is rather important to the few farmers whose farms consist partly of this soil, as it is considerably more fertile and productive than Kalkaska loamy sand with which it is intimately associated.

Antrim sandy loam.—The 6- or 8-inch plow soil of Antrim sandy loam consists of dark-gray or dark grayish-brown sandy loam which is medium acid in reaction. It is underlain by a 2- to 4-inch layer of strongly acid light-gray loamy sand. Below this is an 8- or 10-inch layer of yellowish-brown or grayish-brown strongly acid loamy sand, underlain in most places by a 2- to 4-inch layer of reddish-brown sandy clay; and this, in turn, is underlain by light-brown or grayish-yellow sand or sand and gravel, neutral or alkaline in reaction. Areas including many color and texture variations are mapped as Antrim sandy loam, but, in general, the soil consists of a dark-colored surface soil, which is fairly high in organic matter, overlying sandy loam material that, in turn, overlies coarser sand and gravel at a depth ranging from 2 to 3 feet.

Antrim sandy loam occurs in small areas chiefly in Summit and Riverton Townships. It occupies smooth undulating valley floors or bench positions associated with Emmet sandy loam. Surface drainage is slow, but internal drainage ranges from fair to good. Much of the surrounding higher and hillier land drains over and through the areas of Antrim sandy loam.

Most of this soil is cleared and under cultivation. Tree fruits do well in positions where air and water drainage are not too slow.

Corn, beans, rye, oats, and potatoes yield about the same as or slightly more than on Emmet sandy loam. Owing to its small total area, Antrim sandy loam is not an agriculturally important soil as a whole, but it is important on a few farms.

Emmet sandy loam.—Emmet sandy loam agriculturally is the most important soil of the hardwood hills of Mason County, and it is one of the best soils in the county for the growing of fruit and potatoes. The plow soil consists of a 5- or 6-inch layer of dark-gray or dark grayish-brown acid sandy loam with a medium to low content of organic matter. A few stones and boulders are on the surface and mixed through the upper part of the soil, but their numbers are not great enough to present a serious cultivation problem, except in a few places. The subsoil consists of a 16- to 36-inch layer of light-gray loamy sand or sandy loam in the upper part and yellowish-red sandy clay or light sandy clay in the lower part. The reaction of the subsoil material is medium acid. This horizon, in many places, consists of layers of light-gray sandy loam alternating with layers of various thicknesses of reddish-brown sandy clay. The substratum, or the material below a depth ranging from 3 to 4 feet, is reddish-brown sandy clay with a slight pink cast. It is alkaline in reaction. Pockets of calcareous gray sand and gravel are fairly common in the deep substratum.

Emmet sandy loam, as mapped, covers a range in textural conditions in the hardwood moraine sections of the county (pl. 1, *B*). Included are small areas of deep sand that would have been mapped as Emmet loamy sand had they been larger. Other inclusions resemble Nester loam and Iosco sandy loam or represent gradations between these two soils.

Emmet sandy loam occupies fairly large areas in Summit, Riverton, Custer, and Eden Townships and smaller scattered bodies in other parts of the county. Its total extent is more than 11 square miles.

This soil was developed from sandy clay glacial drift on typical rolling moraines with billowy rounded crests and narrow elongated valleys (pl. 1, *C*). The surface slope ranges from 8 to 16 percent. Heavy machinery can be used on the land, but considerable difficulty is experienced in the use of tractors and binders on the steeper parts. Natural drainage is good, and artificial drainage is not required for the production of fruit or cultivated crops. This soil was developed under a forest cover, mainly of sugar maple, beech, hemlock, basswood, elm, ash, cherry, and ironwood. About 90 percent of the land has been cleared and is now under cultivation. Areas within 5 or 6 miles of Lake Michigan constitute the most productive soil in the county for growing of fruit, and good returns from all fruit trees are obtained if the trees are moderately well cared for. The relief and location of much of this soil are such that air drainage is good and the danger of frost injury is at a minimum. The most consistent yields of potatoes are obtained on Emmet sandy loam and Emmet sandy loam, smooth phase. Acre yields of corn range from 20 to 35 bushels, wheat 10 to 25 bushels, oats 20 to 40 bushels, rye 15 to 25 bushels, potatoes 150 to 300 bushels, beans 5 to 15 bushels, and alfalfa 2 to 3 tons.

The steeper slopes are somewhat subject to water erosion if they are used continuously for clean-cultivated crops, and included sandy spots are subject to wind erosion if they are left bare during the winter. A field of this soil which is allowed to become damaged by erosion and poor methods of cropping returns very poor yields of crops and requires long and costly rebuilding before its former productivity is regained. Stands of alfalfa frequently are obtained without the use of lime, but the risk of failure with this crop is lessened if lime is used. Commercial fertilizers, generally from 100 to 200 pounds of 2-12-6 or 2-16-2, are applied to the cash crops, and all the available barnyard manure is used to maintain crop yields. A 3- to 5-year crop rotation is practiced on most of the farms including this soil.

Emmet sandy loam, smooth phase.—Emmet sandy loam, smooth phase, is, in general, a more desirable soil than typical Emmet sandy loam. It differs from the typical soil in relief and features caused by relief. The plow soil consists of a 5- or 6-inch layer of dark-gray or dark grayish-brown acid sandy loam with a medium or medium-low content of organic matter. A few stones and boulders are on the surface and mixed through the upper part of the soil, but the quantity is not sufficient to present a serious problem, except in a few places. The subsoil consists of a 16- to 30-inch layer consisting of light-gray loamy sand or sandy loam in the upper part and yellowish-red sandy clay or light sandy clay in the lower part. It is medium acid in reaction. This layer in many places is made up of layers of light-gray sandy loam alternating with layers of reddish-brown sandy clay. The substratum material, below a depth ranging from 36 to 48 inches, is reddish-brown light sandy clay or sandy clay, with a pink cast. It is alkaline in reaction, and pockets of calcareous gray sand and gravel are fairly common in the lower part. Considerable textural variation occurs throughout areas mapped as Emmet sandy loam, smooth phase, as it includes many small bodies in which the sandy soil material extends to a depth of more than 5 feet, and other small bodies, in which the soil resembles Nester loam. The relief ranges from smoothly undulating to gently sloping, with the maximum slope less than 8 percent. All types of labor-saving machinery can easily be used on this land.

The larger areas of this soil are in Summit, Riverton, and Custer Townships, west of the village of Free Soil in Grant and Free Soil Townships, and near Fountain in Sherman and Sheridan Townships. Soil of this smooth phase is almost as extensive as the typical soil.

Less run-off of water takes place and the loss from erosion is slighter on this soil than on typical Emmet sandy loam. Water is readily absorbed by the loose open soil which retains a larger supply of water for crops than does the typical soil. Artificial drainage is not necessary for the economical production of crops. In Riverton and Summit Townships, much of this soil is devoted to the production of fruit, but at greater distances from Lake Michigan it is used chiefly for the growing of potatoes, hay, corn, and other general farm crops. Acre yields of corn range from 20 to 40 bushels, wheat 10 to 30 bushels, oats 20 to 40 bushels, rye 15 to 25 bushels, potatoes 150 to 300 bushels, beans 5 to 15 bushels, and alfalfa 2 to 3 tons (pl. 2, A).

In most places water erosion is not serious on this land, although, under poor management, light-textured spots included in mapping are susceptible to wind erosion. In general, management practices for this soil are the same as those for typical Emmet sandy loam.

Emmet sandy loam, steep phase.—The steep phase of Emmet sandy loam includes the steep or broken land associated with areas of Emmet sandy loam. It is rolling or hilly, with steep slopes and narrow hill crests. Much of this steep land has a slope greater than 16 percent.

The soil profile is similar to that of typical Emmet sandy loam, but most of the steeper soil contains more stones and boulders than do typical Emmet sandy loam or Emmet sandy loam, smooth phase.

Practically all of this soil occurs in Summit, Riverton, and Logan Townships, and its total area is not large.

It originally supported a good forest cover consisting dominantly of sugar maple, beech, and hemlock, most of which have been removed. Small areas have been cleared, but at present these are largely pastured or allowed to reforest, as the land is too steep for the economical production of fruits or general farm crops.

Montcalm sandy loam.—The topmost 1- or 2-inch layer of Montcalm sandy loam in cut-over and burned-over, but unplowed, areas consists of very dark gray well-decomposed or finely divided organic matter with some intermingled gray medium sand forming a sandy loam which is underlain by a 2- or 3-inch layer of light-gray leached strongly acid medium sand, and this, in turn, is underlain by a 5- or 6-inch layer of light-brown or yellowish-brown loamy sand or sandy loam, that is strongly acid. The upper two layers and a part of the third layer becomes mixed on plowing to form a gray or light grayish-brown strongly acid light sandy loam. Below a depth ranging from 14 to 24 inches, the material is light brownish-red strongly acid friable sandy clay which is slightly plastic when wet but when dry readily crumbles into fragments ranging from one-fourth to one-half inch in diameter or into grains slightly larger than coarse sand grains. This clay layer generally is slightly acid in reaction in its upper part but, at a depth ranging from 40 to 60 inches, becomes neutral or alkaline. In places the clay is only 8 or 10 inches thick. It gives way to light-brown medium sand or to layers of brown sandy clay alternating with sand, or continues to a depth ranging from 40 to 60 inches, becoming lighter textured and acquiring a pink cast with depth. Even under virgin conditions the content of organic matter in this soil is low. In most places stones and boulders are scattered over and throughout the soil, but the quantity is not sufficient to present a serious problem of removal.

Considerable variations within areas mapped as Montcalm sandy loam exist between the condition described to one in which medium sand extends to a depth of more than 60 inches beneath the third layer and is strongly acid throughout. Another extreme variation has fairly stiff reddish-brown sandy clay or clay exposed on the surface.

This condition is especially apt to occur on slopes. Many areas mapped as Montcalm sandy loam are a complex mixture of these three conditions, but, in general, a comparatively thin layer of light sandy loam overlies layers of slightly acid or neutral sandy clay.

Bodies of this soil occur east of Tallman Lake, southwest of Crystal Lake, north of Fountain, and near the Manistee County line north of Free Soil. The total area mapped is 3.9 square miles. The relief ranges from strongly undulating to gently rolling, or from areas where the slope is not steep enough to present difficulties in the use of labor-saving machinery to slopes on which the use of such machinery is difficult. This soil has developed on moraines from glacial drift, and it has excellent drainage.

The original vegetation probably consisted of a mixed forest of pines and hardwood trees. The pine trees grew to large size, as evidenced by the stumps remaining, and judging from the large interstump spaces it seems probable that beech, maple, hemlock, and oak were associated with the pine. The present growth consists of poplar, oak, a few white and red pines, scattered soft maple, and a ground cover of bracken, sweetfern, and native grasses. About 50 percent of this soil has been cleared, and the rest is pastured or is left as wild land.

The cleared areas that have been placed under cultivation are used chiefly for the production of hay, small grains, corn, potatoes, string beans, and cucumbers. About 10 percent of the cleared land is set to apple trees that are yet too young to indicate what can be expected from fruit on this soil, but the fact that most of the soil is in the eastern half of the county makes it less desirable as regards both location and climate. Yields from the crops grown depend on the quantities of lime, fertilizers, and manures applied to the soil. Among the grain crops, rye makes the best returns. It yields from 8 to 12 bushels an acre under normal conditions. Applications of fertilizer generally are small on this soil, but increased yields could be obtained from larger applications. Fair yields of potatoes, ranging from 75 to 150 bushels an acre, can be obtained under normal conditions, but under a good soil-improvement program larger yields are possible. Corn yields from 10 to 20 bushels an acre, and yields of alfalfa ranging from 1 to 2 tons are obtained after a good stand is established. From 1 to 3 acres of this land are devoted to string beans, cucumbers, or both by some farmers. The acre income from these two crops differs considerably, depending on distribution of the summer rainfall and the prices of beans and pickles, as, in years when the quality is poor or prices low, less beans and cucumbers are picked. Incomes from cucumbers or string beans have ranged from \$50 to \$300 an acre.

No special methods of management are used on this soil. Water and wind erosion are not serious problems, as a rule, during the winter, but, under continuous clean cultivation, the steeper slopes lose their organic matter, after which both wind and water erosion become serious. Most of this soil is worked in a crop rotation, on most farms some variation of a 3- or 5-year rotation, in which clean-cultivated crops are followed by hay and grain crops. Barnyard manure is applied as a soil amendment before the land is plowed for corn, and the small applications of commercial fertilizers, generally from 50 to 100 pounds an acre of 2-12-6 or 2-16-2, are used, for the most part, for string beans and cucumbers. The soil is sufficiently loose and porous that special care in cultivation or plowing following rains is not necessary. The occurrence of this soil in areas which are small, scattered, situated where danger of frost is

relatively great, and closely associated with large areas of deep sandy pine soils, has had a tendency to limit its agricultural development. Soils with less favorable physical characteristics occurring in somewhat larger bodies nearer markets and under better climatic conditions have been developed to a greater extent than has Montcalm sandy loam.

Montcalm sandy loam, steep phase.—Montcalm sandy loam, steep phase, has a 1- or 2-inch layer of very dark gray or black well-decomposed or finely divided organic matter mixed with gray medium sand, forming a very strongly acid sandy loam or light sandy loam. This is underlain by a 2- or 3-inch layer of light-gray leached very strongly acid medium sand. Below this is a 5- or 6-inch layer of light-brown or yellowish-brown strongly acid loamy sand or sandy loam. At a depth ranging from 14 to 24 inches is light brownish-red strongly acid friable sandy clay which is slightly plastic when wet but crumbles to small particles when dry. The material in the upper part of this layer is slightly acid but, in most places, becomes alkaline at a depth ranging from 36 to 48 inches. The texture of the subsoil and the thickness of the sandy covering over clay vary considerably. Within an area of one acre, clay may be exposed at the surface in places and lie more than 60 inches beneath in other places.

This steep soil occurs principally in the vicinities of Gun Lake and Round Lake, and in the central part of Logan Township. Its total area is not large. Although this soil occupies some narrow valleys, and narrow ridges and hilltops where the slope is not excessive, most of the areas have a slope in excess of 18 percent. Such areas are difficult to farm, and the use of heavy machinery on them is impractical. The hilly relief causes rapid run-off of water, and serious erosion would result from cultivation. This soil is developed on typical morainic drift, as indicated by the numerous scattered stones and boulders, as well as pockets of gravel that is used for road and cement work.

Only a few very small areas of this soil have been cleared, and none of the land is under cultivation. The original forest, which consisted of mixed pines and hardwoods, has been cut and burned over. The second growth consists of scrubby oaks, red maple, and poplar, with a ground cover of bracken, sweetfern, wild berries, and grasses.

This soil is too steep for successful or even marginal cultivation and should be left in forest and grass cover for wood and pasture.

SANDS AND LOAMY SANDS

Emmet loamy sand.—Emmet loamy sand is the most important agricultural soil on the sand hills of the county and originally supported a forest cover of hardwoods. The plow soil is dark-gray or grayish-brown loamy sand ranging from medium to low in content of organic matter. This layer ranges from 4 to 6 inches in thickness and is strongly acid. The material is loose, easily worked, and fairly high in organic matter when first plowed, but the supply rapidly becomes depleted under cultivation. In some places, the plow soil is underlain rather abruptly by strongly acid yellow medium sand that extends to a depth ranging from 4 to 5 feet, be-

low which the material is light grayish-yellow medium sand that is neutral or alkaline in reaction. In some places, a 6- to 12-inch layer of dark reddish-brown or umber-brown loamy sand may occur between the plow soil and the underlying sand.

Under virgin conditions, this soil has a layer of slightly acid or neutral dark-brown or black organic matter, about 2 inches thick, underlain by a 4- to 6-inch layer of strongly acid light grayish-brown or lavender-gray medium sand. Below this is a layer of strongly acid umber-brown, dark reddish-brown, or brownish-yellow loamy sand, 6 or 8 inches thick, underlain by grayish-yellow or yellow medium sand which is medium acid and extends to a depth of 30 inches. Below a depth of 30 inches the sand is light grayish yellow, and at a depth ranging from 5 to 8 feet, the material is alkaline. In places, layers or pockets of clay or sandy clay occur at a depth ranging from 4 to 6 feet. In many places the upper soil layers have been removed by the wind, exposing the underlying yellow sand; and a few spots in which the clay layers are within 24 inches of the surface are included in mapping. A few stones and boulders are scattered over the surface as well as through the subsoil and substratum.

The larger areas of Emmet loamy sand are mapped in Pere Marquette Township and the western part of Riverton Township. A total of more than 4 square miles is mapped. The relief is gently rolling or sloping, with rounded hill crests and narrow valleys. The slopes range from 8 to 15 percent, and the land can be farmed by the customary methods used in the county. Considerable difficulty is experienced on the steeper slopes, however, especially in the use of tractors, hay loaders, and binders.

The parent material is glacial drift deposited during the last period of glaciation. Both internal and external drainage of the soil are excellent or excessive. Rapid run-off removes some of the surface soil, and wind erosion may remove the rest. Lack of moisture-holding capacity in the upper layers is a handicap in the production of crops. This soil has developed under a dense forest cover consisting predominantly of sugar maple, beech, and hemlock, with a few elm, basswood, ironwood, hickory, cherry, and some other trees in the original forest.

About 90 percent of the land has at some time been under cultivation, and when first cleared it returned good yields of corn, potatoes, beans, rye, fruits, and other crops grown at the time the county was first settled, but water and wind erosion, together with continuous cropping and practices which returned little or no organic matter to the soil, has resulted in serious depletion of the natural fertility. The drawbacks, together with the greater difficulty in working the sloping land, have caused much of this soil to be placed in pasture.

Rye, beans, corn, potatoes, and fruits are the chief crops grown on areas now cultivated. Acre yields of rye range from 5 to 10 bushels, beans 3 to 10 bushels, and potatoes 25 to 150 bushels. Among the orchard fruits, cherries probably do best, and, if well cared for, fair returns are obtained from the orchards.

It is not considered good practice to set an area of this soil, that has become very low in organic matter, to fruit of any kind until it has been given an expensive rebuilding process. A common practice is to

seed rye which is not harvested but is disked in after it ripens so that it reseeds itself. After this has been continued for several years, lime is added and sweetclover is seeded and plowed under after attaining good growth. After a period ranging from 5 to 8 years of such rebuilding, the land is in good condition for the planting of cherry trees. Special care must be exercised in cultivation of this soil. It should not be left bare over winter, as washing by spring rains and the action of wind are very detrimental to it.

Emmet loamy sand, smooth phase.—Emmet loamy sand, smooth phase, differs from typical Emmet loamy sand in relief and differences caused by relief. It ranges from strongly undulating to gently sloping, with slopes not greater than 8 percent, and can be worked readily with all types of labor-saving machinery. Owing to slow run-off, water readily percolates into the loose-structured soil, so that more water is stored and the loss of plant nutrients by erosion is not so great. Small areas of Emmet sandy loam have been included with this soil in mapping and these increase its value.

Emmet loamy sand, smooth phase, is developed in Summit, River-ton, Eden, and Sherman Townships in large and scattered small bodies. This soil has developed on sandy glacial drift and it contains fewer stones and boulders than does typical Emmet loamy sand.

Acre yields of rye range from 5 to 20 bushels, beans 3 to 15 bushels, potatoes 50 to 200 bushels, alfalfa 1 to 2 tons, and corn 10 to 25 bushels. Good returns of string beans and cucumbers are obtained, and fair to good returns are sometimes obtained from both tree and small fruits.

This soil can be built up to a fairly high state of productivity by careful management and returning large quantities of organic matter in the form of green and barnyard manures. Wind erosion is not serious on this soil unless it is handled carelessly. When an area of this soil becomes badly run down it is difficult and expensive to build up again.

Emmet loamy sand, steep phase.—Emmet loamy sand, steep phase, is closely associated with typical Emmet loamy sand in places where the land is steep and hilly with sharp steep slopes greater than 18 percent. The profile of this soil under virgin conditions is similar to that of typical Emmet loamy sand.

Some areas of this soil have been cleared, and, after a few years of washing and blowing, only yellow sand remains, with a few stones and gravel scattered over the surface (pl. 2, A). The native forest cover was dominantly sugar maple, beech, and hemlock. Practically none of this soil is being placed under cultivation at present but is left as woodland, and that formerly cleared is largely in pasture or is worthless, eroded, waste land.

Weare fine sand.—Weare fine sand is a sand soil, occurring on ridges, intermediate in age and development between Bridgman fine sand and Wallace fine sand. The plow soil consists of light grayish-brown or gray loamy sand, low in organic matter and strongly acid. It is incoherent and readily blown by the wind when in clean cultivation. Under cultivation, the plow soil in most places is underlain abruptly by yellow acid fine sand, and this, in turn, is underlain, at a depth ranging from 18 to 24 inches, by grayish-yellow acid sand which continues to a depth of more than 5 feet. The virgin soil has

a 1- or 2-inch layer of dark-gray organic matter intermixed with fine sand which is acid in reaction, underlain by a 2- to 4-inch layer of ash-gray or lavender-gray very strongly acid leached fine sand. Below this is a 4- to 6-inch layer of dark-brown or brownish-yellow strongly acid fine sand underlain, at a depth ranging from 14 to 18 inches, by loose incoherent yellow or grayish-yellow strongly acid fine sand. The color profile of areas mapped as Weare fine sand includes considerable variations, owing to the shifting of the upper soil layers by the wind. Blow-outs are common in this soil, and a large number of areas have had 75 percent of their surface changed by blow-outs (pl. 2, B).

This soil occurs in small areas scattered over the western part of the county, and larger areas are north of Ludington, north of Lincoln Lake, and between Ludington and Scottville. The total area mapped is slightly more than 11 square miles.

The relief is ridgy, choppy, or rolling, with moundlike ridges rising from 10 to 30 feet above the level of the surrounding plain. It may occupy a narrow ridge, ranging from 100 to 200 feet in width, extending across a wide plain, or it may occupy a series of ridges alternating with narrow valleys, in which the soil has the same profile as that on the ridge tops. Most of the slopes are not excessively steep for farming. These ridges, mounds, or hills are low dunes, piled up by the wind, that have remained in place long enough to develop a definite soil-color profile. They occur both along the edges and across the sandy lake plains. This soil is excessively drained.

At the time white men first entered the county this soil was covered with a good stand of timber, in which the predominating trees were white pine, but in areas where the ridges are associated with the hardwood plains the land supported a good stand of beech, maple, hemlock, and associated trees.

Probably one-half of this soil has been cleared but nearly one-half of the cleared land has been invaded by blow-outs which have caused such serious damage that 90 percent of the total area is now in grass for pasture and hay. The most important grass probably is quack-grass although some bluegrass and timothy are also present. In a few places where a large proportion of the land on the farm consists of better soil, fruit trees receiving good care produce fair returns on areas of this soil. Fair crops of string beans and rye are obtained on farms where the sand has been kept under control and not allowed to blow or drift. Small crops of rye and corn are obtained where large quantities of organic matter have been applied in the form of green and barnyard manures.

The ideal use for this land is probably for forestry. It makes good spring and late fall pasture, but close grazing and heavy trampling during the dry summer months is likely to start blow-outs. The areas of Weare fine sand afford good well-drained building sites, but it is difficult to maintain a lawn, and blowing of the sand is likely to occur around barns and outbuildings if a grass cover is not maintained. Under a forest or brush cover, this soil should not be cleared for agricultural purposes. Small garden spots may be successful where surrounded by trees and brush to break the force of the wind, provided plenty of organic matter and other soil amendments are applied.

Echo loamy sand.—Echo loamy sand is the soil mapped in the bottoms of the dry hollows and valleys, in association with Emmet loamy sand. It has a surface, or plow, soil of dark-gray or very dark grayish-brown loamy sand, ranging from 8 to 12 inches in thickness, which is fairly high in organic matter, owing to wash from the adjoining hills. The material in this layer ranges from slightly acid to strongly acid. To a depth ranging from 18 to 24 inches is the subsoil of medium sand which ranges from dark reddish brown to light yellowish brown and is strongly acid. The underlying material is gray or grayish-yellow medium sand which is neutral in reaction.

This soil is associated with Emmet loamy sand, chiefly in Summit and Riverton Townships. Its total area is small. It occupies valleys in the morainic drift area, and the relief ranges from undulating to slightly sloping. Natural drainage is sufficient for the production of all the crops commonly grown, and, as moisture is received through run-off from the adjoining hills as well as some from seepage, this soil does not become so dry as the other loamy sand soils. Originally the land was forested with hardwoods.

Owing to the small size of the individual areas, this is not an important agricultural soil, but when cleared and farmed it returns better yields of fruits and general crops than do the adjoining upland areas of Emmet loamy sand. Fruit trees grow rapidly, and fair yields of all farm crops are obtained. Acre yields of rye range from 10 to 20 bushels, beans 3 to 15 bushels, potatoes 50 to 200 bushels, corn 10 to 25 bushels, and hay 1 to 3 tons. This soil can be built up to a highly productive state, but, owing to the small irregular shape and inaccessibility of many areas, more than one-half of it is pastured or left in wood lots.

Kalkaska loamy sand.—Kalkaska loamy sand is the principal soil of the dry sand plains that originally were covered with hardwood forest. The 4- to 6-inch plow soil is dark-gray or grayish-brown loose mellow loamy sand which is strongly acid. Beneath this is a layer of dark reddish-brown or umber-brown loamy sand, also strongly acid, and below this is yellowish-brown medium sand which in places becomes grayish yellow at a depth ranging from 24 to 36 inches. This material continues to a depth of more than 5 feet. When first cleared and plowed the organic-matter content is medium high, but this material is soon lost under cultivation.

A few small areas resembling Arenac loamy sand and Saugatuck sand and a few small areas of Wallace fine sand and Weare fine sand are included with Kalkaska loamy sand in mapping, but, as a whole, areas mapped as Kalkaska loamy sand are very uniform in texture, color, and depth of sand. Large bodies are in Victory and Grant Townships, and smaller areas are in Summit Township and elsewhere. The total area is 22 square miles.

This soil occurs on smooth undulating or nearly flat outwash or lake plains. Its relief is ideal for the extensive use of farming machinery. Drainage is thorough, and dryness is one characteristic of this soil, that limits crop production and land use.

Originally the soil was entirely forested by a good stand of sugar maple, beech, and hemlock as the dominant trees, associated with elm, ash, soft maple, and other species. About 50 percent of this land has

been cleared, as it was once thought that any soil supporting a good stand of hardwood timber had excellent agricultural possibilities, but probably one-half of the once-cleared land is now either abandoned or is used for pasture.

The areas under cultivation are cropped to corn, beans, wheat, rye, oats, potatoes, and hay. Approximately 10 percent of the cultivated land is devoted to corn, oats, and beans; 15 percent to rye and wheat; about 5 percent to potatoes; and the rest to hay and pasture. Yields differ widely and range from the average for the county to slightly less, depending on the season, the length of time a given field has been under cultivation, and the care that has been taken to prevent wind erosion. Many fair-sized areas have lost enough of their plow soil that they are nearly useless for pasture.

Beans yield from 5 to 15 bushels an acre, corn 10 to 20 bushels, rye and wheat 10 to 15 bushels, potatoes 50 to 150 bushels and possibly higher under virgin conditions, oats 20 to 30 bushels, and hay about 1½ tons.

When the land was first cleared, good yields of cultivated and grain crops were obtained for a few years, as the virgin soil contained considerable readily available plant nutrients, but, without large numbers of livestock and the use of a farming system which returned organic matter to the soil, the natural fertility was depleted quickly. As larger areas were cleared, wind began to drift the valuable surface soil and complete the havoc of overcropping. Only a few well-cared-for areas of this soil still produce a living for the farm operators.

Kalkaska loamy sand, slope phase.—Kalkaska loamy sand, slope phase, is closely associated with typical Kalkaska loamy sand and is distinguished from it by the sloping terrain. The soil profile, so far as it has not been destroyed by erosion, is similar to that of typical Kalkaska loamy sand. In places this land constitutes the valley slopes of streams cutting through areas of Kalkaska loamy sand, and it is also mapped to include pitted and strongly sloping areas in otherwise smooth plains.

A few small areas are scattered throughout the western part of the county, mainly in Grant, Victory, and Amber Townships. This sloping land is used almost entirely for pasture and wood lots.

Roselawn loamy sand.—Roselawn loamy sand is the sand soil of the rolling to hilly pinelands. Under virgin conditions it has a thin layer of acid organic matter or litter, composed of leaves, twigs, and pine needles, overlying a layer of mineral soil, from 1 to 3 inches thick, of leached gray or light grayish-brown medium sand and fine sand, which are strongly acid. This material is underlain by an 8- or 10-inch layer of strongly acid brownish-yellow or yellowish-brown loamy sand stained by organic matter. Under cultivation the upper two layers and a part of the third become mixed to form a grayish-brown loamy sand plow soil which is low in organic matter and strongly acid. In a freshly plowed field, the color ranges from gray to yellowish brown. The next lower layer consists of strongly acid yellow or grayish-yellow medium sand which extends to a depth of more than 5 feet. In many places, nearly pure sand continues to a greater depth; in small areas, yellowish-red or brownish-red sandy clay occurs at a depth of 4 or 5 feet; and only in a few places does

clay occur within 36 inches of the surface. In a few places, pockets of gravel are from 18 to 30 inches beneath the surface.

Extensive areas of Roselawn loamy sand are developed in the vicinities of Blue Lake, Gun Lake, and Ford Lake; east of Round Lake; and in Logan and Eden Townships. The total area mapped is 35.5 square miles. This soil has formed on sandy glacial drift, and the relief, in general, is gently rolling or rolling. Most of the included slopes range from 8 to 25 percent and, in a few places, are in excess of 25 percent. The land is billowy, with rounded ridges, and includes narrow dry valleys. Many small lakes and small pockets of peat or muck are in basins between the ridges or hills, but most of the soil is well drained because of the loose pervious substratum.

Originally this land was forested with a good stand of white pine and red pine, with possibly a few scattered oaks or other deciduous trees. None of the original forest remains, but the land supports a second growth of oaks, aspen, pin cherry, red maple, and a few beech and sugar maple, with a ground cover of bracken, sweetfern, witch-hazel, blueberries, and some native grasses. Numerous small areas support a grass cover between pine stumps, and many old clearings once farmed are now grown up to grass and sweetfern.

Only a few scattered areas of this soil are cultivated. Yields of corn, beans, and rye are only fair, even on new land, and, as it is impossible for most of the people working such areas to apply large quantities of manure, fertilizer, and lime, yields diminish each succeeding year. Lack of moisture also is an important limiting factor in plant growth on this soil. Considerable areas are pastured, as spring and fall pasture generally is good, and, if the number of livestock is not too large, the pasture will carry the animals through the summer. In some places it may be necessary to drive wells, in order to provide water for the livestock. The land provides from fair to good game cover. Under cultivation, great care must be exercised to prevent both wind and water erosion.

Roselawn loamy sand, smooth phase.—The smooth phase of Roselawn loamy sand differs from typical Roselawn loamy sand, with which it is closely associated, only in relief. It has the same moisture and plant-nutrient deficiencies as have Roselawn loamy sand and Rubicon sand. In some places, pockets of coarse gravel and sand mixtures occur from 18 to 36 inches beneath the surface.

One of the larger areas of this soil surrounds Tallman Lake in Branch Township. This soil is much less extensive than the typical soil. It is used in a similar manner, as pasture, woodland, and waste land for game refuges. A few small areas are planted to beans, corn, potatoes, rye, and a few vegetables, as subsistence crops, generally in connection with fur farming or some line of endeavor other than a strictly agricultural one. Yields, even with large applications of manure and commercial fertilizers, are limited by the low moisture-holding capacity of the soil; consequently only poor returns may be expected.

Rubicon sand.—Rubicon sand is the most extensive soil in the county. It occupies large bodies, chiefly on the nearly level pine plains in Hamlin, Grant, Free Soil, Meade, Branch, Eden, and Logan Townships.

Under virgin conditions, Rubicon sand has a thin layer of very dark grayish-brown or black forest litter, loosely bound together with fine roots and containing a very small quantity of light-gray sand particles mixed in the lower part. The material in this layer is medium acid in reaction. The mineral soil consists of a 2- to 4-inch layer of gray or light-gray strongly acid medium sand underlain by an 8-inch layer of light-brown or yellowish-brown strongly acid medium sand, with a slightly loamy feel. Under cultivation, the upper two layers and a part of the third layer are mixed, resulting in a light-gray or grayish-brown plow soil containing brownish-yellow spots in those places where more of the third layer has been more recently plowed up. The plow soil, under unlimed conditions, is strongly acid. Below a depth ranging from 12 to 18 inches is yellow or grayish-yellow strongly acid medium sand. Loose dry acid sand extends to a depth of more than 5 feet.

As this soil is loose, open, and porous, water is absorbed readily and roots easily penetrate to all depths. Even under virgin conditions, the supply of organic matter is small, and it quickly becomes depleted after a few years of cultivation. Rubicon sand is free of stones and does not differ much in texture from place to place. Some very small wet areas, described elsewhere as Saugatuck sand, Newton sand, and Arenac loamy sand, are included in areas mapped as Rubicon sand. The relief is undulating or nearly flat, and none of the slopes is steep enough to hinder the use of any type of farm machinery.

This soil has developed mainly on glacial outwash plains. It originally supported a dense to medium stand of white pine and red pine. All the land has been cut-over, but the stumps on uncleared areas indicate that these two trees must have predominated. The present second growth consists of a few scattered white pine and red pine, numerous quaking aspen and largetooth aspen, red maple, silver maple, oaks, sweetfern, bracken, raspberries, sumac, witch-hazel, sassafras, blueberries, grasses, and many different weeds.

Rubicon sand is low in plant nutrients, and the moisture-holding capacity is very poor. It is incapable of maturing crops, with even meager yields, for more than a very few years (probably less than 5) without heavy applications of manure and commercial fertilizer. Only small areas are farmed, and these are associated with some heavier soils on which quantities of lime, manure, and fertilizers can be applied profitably. Small to medium yields of corn, rye, beans, and alfalfa hay are obtained. Rye probably makes the best returns of any cultivated crop on this soil. It is barely possible that future economic conditions may make it profitable to cultivate this soil under some extensive farming system that will allow the removal of a crop in alternate years or every third year. Under present conditions, the land furnishes fair spring, early summer, and late fall pasture and should be used for that purpose or allowed to reforest.

In attempting to cultivate small areas of this soil, where it seems desirable to do so in association with areas of Iosco, Nester, Emmet, Montcalm or some other of the somewhat better soils, especial care must be used in its management, in order to prevent wind erosion and to build up and maintain the organic matter in the soil. Increas-

ing the organic-matter content will aid in holding more moisture, promote plant growth, and reduce the tendency of the soil to wind erosion. In order to obtain most profitable results from the fertilizers used, it will be necessary to apply lime or marl. Acre applications ranging from 4 to 6 tons of such material seem necessary on this soil, or smaller applications may be used at intervals ranging from 2 to 4 years. Probably it would be more profitable to cultivate the heavier soils more intensively and use any sizable fields of Rubicon sand for pasture or woodland.

Rubicon sand, slope phase.—Rubicon sand, slope phase, a soil developed from deep sands of the pine plains, has more sloping relief than typical Rubicon sand. The surface soil contains less organic matter than the typical soil, owing to erosion on the slopes. A 2- to 4-inch leached layer of light grayish-brown sand is beneath the organic layer, and this, in turn, is underlain by a 3- or 4-inch layer of yellowish-brown sand. At a depth of 18 inches, the material is grayish-yellow medium sand. This soil is strongly acid to a depth of 5 feet or deeper.

This sloping soil occupies small areas associated with the larger areas of the typical soil. It occurs on broken sand plains, most of it on slopes toward streams or slopes dividing two levels of a plain. The gradient of the slopes ranges from 7 to 15 percent.

The original cover was pine. This has been cut, and a second growth of scrub oaks and poplars is coming in. None of this soil is under cultivation, but it is used for pasture or left as wild land. It has about the same potential value as have Rubicon sand and Roselawn loamy sand.

Rubicon fine sand.—Under forest conditions Rubicon fine sand is covered with a 1- or 2-inch layer of very dark brown or black forest litter composed of disintegrated leaves and twigs bound together by fine roots. The lower part of this layer, in contact with the mineral soil, is black finely divided organic matter with a few grains of soil mixed in. It is medium to strongly acid. The layer of organic material overlies a 2- to 4-inch layer of strongly acid gray or light-gray fine sand. In places the topmost inch of this layer is stained dark gray with organic matter washed from the organic layer. Below this is a 4- to 6-inch layer of strongly acid light-brown or yellowish-brown fine sand or slightly loamy fine sand. Under cultivation the upper two layers and part of the third layer become mixed to form gray or light grayish-brown fine sand or loamy fine sand which is strongly acid. Below a depth of 18 or 20 inches and extending to a depth of more than 60 inches, is grayish-yellow or light-yellow fine sand and very fine sand, which is strongly acid. In places, layers of medium fine sand or silt are in deeper parts of this layer.

Included with this soil as mapped are narrow strips, ranging from 20 to 50 feet in width, of lower wetter old river beds that may have a 3- to 6-inch layer of muck over light-gray fine sand. Some of these strips are only a few hundred feet long, others nearly surround areas of typical Rubicon fine sand.

Small areas of Rubicon fine sand border Pere Marquette River east of Scottville, others occur along the south branch of that river.

The land is flat or undulating, and most of the areas are separated from the adjoining soils by a short steep slope ranging from 20 to 50 feet in length and with a gradient of more than 20 percent.

This soil occupies terraces, or second bottoms, and has been developed from material deposited by the river before the stream had cut its bed to the present level. Both surface and internal drainage are good, although some of the included low spots along the boundaries are poorly drained. The present vegetation is a mixed forest of sugar maple, beech, hemlock, birch, a few white pine, poplar, soft maple, and elm.

Rubicon fine sand is somewhat superior to Rubicon sand in water-holding capacity, but, as it occurs in small inaccessible areas, none of it is under cultivation. A few areas have been cultivated in the past, but the area available was so small and the associated soils so poor that all this land has been abandoned.

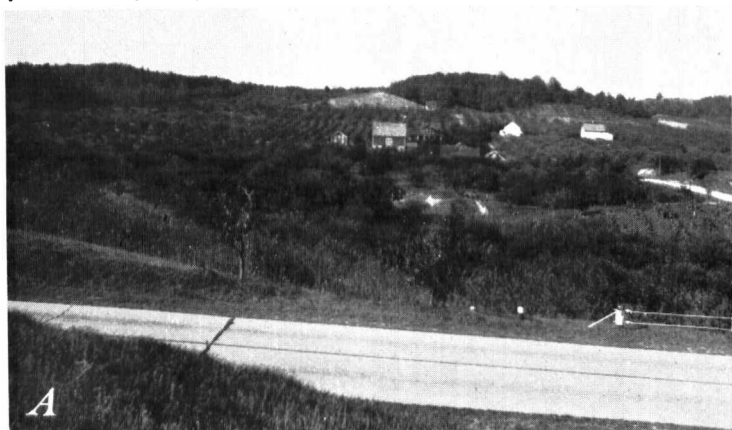
Grayling sand.—Grayling sand under unplowed conditions is covered with a $\frac{1}{4}$ - to $\frac{1}{2}$ -inch layer of slightly acid dark-brown organic matter composed chiefly of oak leaves. It is underlain by a $\frac{1}{2}$ - to 1-inch layer of mineral soil consisting of light-gray sand, which in places is missing, overlying a 2- or 3-inch layer of a mixture of light-gray medium sand and light-brown organic matter that has been washed and pressed into the sand. The material in both layers is very strongly acid. Between depths of 3 and 20 inches is yellow or brownish-yellow medium sand. In places, at the top of this layer, is a 1- to 3-inch layer of definitely developed yellowish-brown sand. All the material in this layer is strongly acid. Below a depth of 20 inches is strongly acid grayish-yellow dry medium sand which extends to a depth of more than 6 feet.

Included in areas mapped as Grayling sand is one area in sections 4 and 5 of Meade Township where clay occurs at a depth ranging from 3 to 4 feet below the surface. The soil in this area supports a slightly better forest growth than does typical Grayling sand.

More than 40 square miles of Grayling sand are mapped in Mason County. Large areas are in Meade, Branch, and Free Soil Townships. The relief ranges from nearly flat to undulating, the undulations apparently having been caused by action of the wind. This soil has been developed on dry sand outwash and dry sand lake beds.

At present the land is forested with a more or less open stand of oak, wild cherry, and various quantities of jack pine. In some places the cover consists of deciduous trees, and in other places in the same large area the cover may be a dense stand of small jack pine from 3 to 6 inches in diameter and from 10 to 20 feet high. In other places the cover may be a mixture of oak, cherry, and jack pine, with oak and jack pine predominating. Judging from stumps in some old clearings the original forest on this soil was not dense. Numerous old clearings, house sites, deserted houses, and shacks bear mute testimony of the impossibility of successful agriculture on Grayling sand. This land has some value as grazing land, as it supports a fair growth of native grass in places where the trees are not too thick. Some wood for fuel and posts can be obtained from the forest cover.

Grayling sand, slope phase.—Grayling sand, slope phase, occurs chiefly in the northeastern part of Meade Township. It differs from



A, Orchard in Summit Township; *B*, Emmet soils in Summit Township; *C*, scene showing typical relief of Emmet sandy loam.



A, Alfalfa growing on Emmet sandy loam in the foreground; orchard on the same soil in the middleground; and Emmet loamy sand, steep phase, showing effect of wind erosion in the background. *B*, Blow-outs on Weare fine sand. *C*, Profile of Ogemaw sandy loam showing variations in the thickness of the sandy loam covering over clay.

typical Grayling sand only in its dune or dunelike surface configuration. A few areas mapped in Branch Township include remnants of broken or pitted plains, in association with Grayling sand. In some places the hollows and valleys contain a soil similar to Echo sand, and in other places flats occur, on which the soil is mapped as Saugatuck sand, drained phase. This phase of Grayling sand is no more valuable than typical Grayling sand, except that it provides slightly better cover for game.

Wallace fine sand.—Wallace fine sand is a soil of the pineland ridges, associated with the sand plains of the county. Under virgin conditions it has a thin dark-brown mat of partly disintegrated organic matter made up of rotten wood, twigs, and leaves, which is slightly acid, overlying a 6- or 8-inch layer of light-gray or lavender-gray strongly acid fine sand slightly stained with organic matter in the upper part. Below this is a hardpan layer consisting of dark reddish-brown, umber-brown, or coffee-brown cemented fine sand or slightly loamy fine sand, which is strongly acid in reaction. In many places fingers, or projections, of this hardpan layer extend from 3 to 4 feet into the underlying material which consists of gray or yellowish-gray pervious fine sand. This material continues to a depth of more than 60 inches and is strongly acid. The hardpan layer contains seams, cracks, or breaks, which allow roots to penetrate it and reach the substratum. In a few places the hardpan layer is absent, owing, probably, to its having been destroyed by more recent shifting of the sand by the wind, a process which accounts for the principal variations in this soil. Blow-outs are common, and large areas show evidence of recent and present drifting.

Areas of Wallace fine sand are scattered over much of the county in the form of ridges along old lake beaches. They extend in a general northwest-southeast direction. One of the more prominent areas is between 3 and 4 miles north of Scottville. These ridges range in height from 10 to 50 feet above the surrounding plain and in width from 50 feet to one-fourth mile. As a rule, the eastern slopes of the ridges are short and steep, with a gradient in excess of 20 percent, but the western slopes are longer and less steep. Originally these areas were forested principally with white pine and red pine, but the present cover consists of poplar, red maple, white birch, oaks, a few white pine and red pine, and a ground cover of bracken, sweetfern, and native grasses.

In a few places where narrow ridges of Wallace fine sand cross fields of moderately valuable soil, the Wallace soil is farmed in the same manner as the other soil, but it requires heavy applications of manure to maintain sufficient plant growth to keep it from developing blow-out spots. At the best, crop yields are very poor on this soil, and most of the cultivated areas have been abandoned to pasture, second-growth trees, and brush. Owing to its poor moisture-holding capacity and low plant-nutrient content it should not be used for agricultural purposes. In using such areas as sites for houses or other buildings, care must be taken to prevent blowing, as severe blow-outs may undermine the foundations.

Saugatuck sand, drained phase.—Saugatuck sand, drained phase, has a thin layer of dark grayish-brown very strongly acid organic matter overlying a 2- or 3-inch layer of very strongly acid light-gray

or gray sand. Below this is a very strongly acid brown hardpan layer consisting of cemented sand, ranging from 6 to 12 inches in thickness. In places, this layer is soft enough when moist for roots to penetrate it. Below a depth of 12 inches is grayish-yellow or grayish-brown medium sand which is very strongly acid and contains some bright-yellow mottlings or splotches, indicating poor drainage in the past. Within areas mapped as Saugatuck sand, drained phase, there are places where the brown hardpan is missing. Such spots would have been mapped as Newton loamy sand, drained phase, had they been large enough to indicate on a map of the scale used.

Saugatuck sand, drained phase, occupies very small areas in the northeastern part of Meade Township. The areas are nearly flat. This soil was developed under poor drainage, but subsequently there was a natural lowering of the water table.

The forest cover consists chiefly of jack pine, scrubby white oak, red oak, jack oak, and pin cherry. The ground cover consists of willow, bracken, sweetfern, dewberries, and wintergreen. None of this soil is cleared and at present has no agricultural value. The vegetation forms a good cover for game.

Newton loamy sand, drained phase.—The topmost 2- or 3-inch layer of Newton loamy sand, drained phase, consists of strongly acid dark-gray or grayish-brown loamy sand composed of a mixture of well-decomposed organic matter and medium fine sand. It is underlain by a layer of dingy-gray or light grayish-brown loose strongly acid medium and fine sand, 9 or 10 inches thick, and this, in turn, is underlain by grayish-yellow strongly acid medium sand. Below a depth ranging from 36 to 48 inches, brown streaks and faint mottlings indicate that the water table was high at one time but has been lowered by natural channels. Dry sand extends to a depth of 5 or more feet.

Included in areas mapped as Newton loamy sand, drained phase, are a few areas of Saugatuck sand, drained phase, that are too small to separate. Where this soil grades into Grayling sand, a few areas of Grayling sand may be included.

All this soil occurs in the eastern part of Meade Township, where it covers a total area of 2 square miles.

The land is nearly flat. The present cover consists of scattered small pin cherry, jack pine, low willows, and native grasses. No attempt has been made to farm this soil.

Bridgman fine sand.—Bridgman fine sand is the soil of the forested dunes. It has a thin surface layer of dark-brown organic matter, which is strongly acid, underlain by the mineral soil consisting of a 2- to 4-inch layer of light-gray or nearly white very strongly acid fine sand. This, in turn, is underlain by a thin layer of yellow fine sand grading, below a depth ranging from 4 to 8 inches, into a layer of grayish-yellow or light-gray very strongly acid fine sand of variable thickness, depending on the height of the dune. In some places a somewhat pronounced color profile has developed, and in other spots there is little change from the original deposit.

This soil borders Lake Michigan, most of it lying between that lake and Hamlin Lake. The relief is that common to the Lake Michigan

dunes, that is, a series of ridges and hills with steep eastern sides, narrow tops, gradual western slopes, and narrow intervening basins. Bridgman fine sand is distinguished from dune sand by its occurrence on the stationary forested dunes, whereas dune sand comprises bare shifting sands.

The forest cover is diversified, including cedar, spruce, poplar, oaks, red maple, paper birch, juniper, a few beech, and pines.

Most of the larger areas of moving sand now present in the dunes probably were caused by timber cutting and fire. If the slow-growing vegetation is once removed from the dry sand, shifting usually starts before vegetation again becomes established. None of this land is farmed.

Owing to the fact that the air is clean and comparatively cool on the hottest summer days in the forest on the dunes, areas of Bridgman fine sand are popular sites for summer cottages. A public park has been established in the area of this soil lying between Hamlin Lake and Lake Michigan.

Dune sand.—Dune sand comprises the gray fine sand directly along Lake Michigan or a short distance back from the shore, that continually is being shifted by the wind. Some bare areas now mapped as dune sand originally had a forest cover, and other forested areas have been covered by the sand shifting inland. Considerable areas of dune sand are now covered with beachgrass which slows the shifting to some extent and is an important agent in stabilizing the sand.

In the past, large quantities of this sand have been shipped away for commercial purposes, but at present no commercial use is made of it.

IMPERFECTLY DRAINED SOILS

SANDY LOAMS

Ogemaw sandy loam.—Ogemaw sandy loam has a dark-gray or dark grayish-brown loose sandy loam layer, fairly high in organic matter, strongly acid, and from 4 to 6 inches thick, underlain by light-gray strongly acid loamy sand from 4 to 6 inches thick. Below this is a dark-brown hardpan or partly cemented loamy sand, which is strongly acid and ranges in thickness from 2 inches to as much as 24 inches. In some places it directly overlies clay, but in most places a 4- to 8-inch layer of dingy-gray sand mottled with brown and bright yellow is between the hardpan and the underlying red or yellowish-red stiff heavy calcareous impervious clay. The total thickness of the sandy layers ranges from 18 to 36 inches, and in many places the hardpan layer is so near the surface that it is broken up and mixed with the surface soil by plowing (pl. 2, *C*). In small included areas the clay is near enough to the surface to form Selkirk silt loam. Areas of Bergland loam and Munuscong sandy loam also have been included, as they are too small to separate on a map of the scale used. In some areas the underlying clay is somewhat sandy, but it is sufficiently impervious that a profile essentially like that of Ogemaw sandy loam is developed.

Ogemaw sandy loam occurs in Riverton, Eden, Amber, Custer, and Sherman Townships, in bodies of sufficient size to be of agricultural importance. The total area is 22.7 square miles.

This soil occurs on smooth plains where a deposit of light sandy material has been spread over heavy clay. The relief ranges from smooth or nearly flat to undulating. Surface drainage is slow and, although water readily penetrates the upper part of the soil, its downward movement is retarded by the clay substratum, and some type of artificial drainage is needed for best results with most farm crops. The original forest cover consisted largely of mixed hardwoods and white pines.

About 90 percent of Ogemaw sandy loam, locally called "hardpan soil," has been cleared and put under cultivation. This soil is closely associated with Selkirk silt loam; hence these two soils are similarly cropped. On a farm consisting largely of Selkirk silt loam, an area of Ogemaw sandy loam generally is chosen for potatoes, berries, cucumbers, or string beans, as these crops do better on the lighter textured soil than on Selkirk silt loam. Alfalfa produces better on Selkirk silt loam than on Ogemaw sandy loam. It requires from 2 to 5 tons an acre of lime on Ogemaw sandy loam to insure a stand of alfalfa, and heavier applications of lime, manure, and fertilizer are generally applied to fields of this soil than to the associated heavier soil. Acre yields of corn range from 15 to 30 bushels, wheat 5 to 20 bushels, oats 15 to 45 bushels, rye 5 to 20 bushels, potatoes 75 to 300 bushels, beans 5 to 15 bushels, and alfalfa 1 to 3 tons.

This is not considered a good soil for fruit trees, and few have been planted on it, as the sandier part of the soil stays wet enough during the spring and fall to cause injury to the roots. The artificial drainage systems consist of a few shallow open ditches emptying into larger ditches or streams, and, owing to the difficulty of working around them, such feeder drains are few, shallow, and not very efficient in draining the areas involved.

Iosco sandy loam.—Iosco sandy loam is a rather wet soil consisting of from 2 to 3 feet of sandy loam material over heavy clay. The 4- to 6-inch plow soil is dark-gray or dark grayish-brown medium to strongly acid sandy loam. It is loose, friable, easily worked, and has a low to medium organic-matter content. A few small lumps of reddish-brown cemented material, the remains of an old hardpan that has been broken up by plowing, are mixed through the plow soil. Below the plow soil is a 4- to 8-inch layer of dark reddish-brown or dark-brown loamy sand or sandy loam, that tends to form a hardpan in places. It may occur near enough to the surface that it has become mixed with the plow soil, but in most places it is not dense enough to hinder the penetration of roots or water. This layer is strongly acid. At a depth ranging from 16 to 24 inches, the material is light grayish-yellow wet sandy loam or loamy sand, slightly streaked and mottled with light yellow. It is medium to strongly acid. Below a depth ranging from 24 to 36 inches is yellowish-red or yellowish-brown calcareous clay or sandy clay. Gravel, stones, or boulders are not present in sufficient numbers to cause difficulty in cultivation of this soil. In this county, this soil type was mapped to cover a range in soil conditions from the one described to soil in which the clay layer is only 6 or 8 inches beneath the surface. In areas with such shallow sandy covering the soil is gradational toward Nester loam. In some areas, the underlying clay does not occur in one continuous body but consists of yellowish-

brown sandy clay streaked with light-gray or dingy-gray sandy loam. In such places layers of sand or sandy loam alternate with layers of clay or light sandy clay, and the reaction ranges from slightly acid in the upper part of the clay layer to alkaline at a depth ranging from 3 to 4 feet. In general, a thin layer of acid sandy loam overlies impervious or slightly pervious clay, the thickness of the sandy loam layer ranging from 1 to 4 feet.

Iosco sandy loam is distinguished from Ogemaw sandy loam in that it has better natural drainage, less tendency for the brown layer to be indurated into a hardpan, and a more sloping or rolling relief. It differs from Emmet sandy loam in that it has less thorough drainage, in general a heavier textured substratum, and, in places, a hardpan layer that is not characteristic of Emmet sandy loam. The Iosco soil occupies till plains or ground moraines formed by the glaciers. Most of it has been developed from sand deposited by wind or water over the glacial till. Fairly large areas are in Victory, Meade, Riverton, and Eden Townships. Its total area is not large.

The relief ranges from undulating to gently sloping, most of the slopes having a gradient of less than 8 percent, although a few small scattered areas are included, in which the slope is as much as 15 percent, but such slopes are short. Surface drainage is good in most places. Water readily enters the upper part of the soil, but its downward movement is retarded by the clay substratum, therefore internal drainage is imperfect or slow. This soil has developed under forest consisting of sugar maple, beech, hemlock, and associated trees.

Iosco sandy loam is intimately associated with Nester loam, and, as a rule, the two soils are planted to practically the same crops. Under continuous cropping without the use of large quantities of soil amendments, yields rapidly fall behind those obtained from Nester loam under the same management. Under the usual cropping conditions, corn yields from 20 to 40 bushels an acre, wheat 10 to 30 bushels, oats 20 to 45 bushels, rye 15 to 25 bushels, potatoes 100 to 300 bushels, and alfalfa hay 2 to 3 tons.

About 90 percent of the total area of this soil has been cleared and is either under cultivation or is pastured. Probably 10 percent of the land is devoted to each of the following crops: Corn, wheat, oats, and beans. Smaller acreages are in potatoes, string beans, and cucumbers; and the rest is hay and pasture land.

Lime in some form generally is applied at a rate ranging from 2 to 5 tons an acre before seeding the land to alfalfa. Available manure is applied as heavily as convenient to this soil, and green manures, usually rye, sweetclover, or buckwheat, are plowed under occasionally by some farmers.

Although this soil may be plowed or worked over a wide range of moisture content, the associated and included spots of heavier soil cannot, without troublesome results. Plowing the latter spots when they are too wet injures their tilth to such an extent that their productivity is reduced temporarily, although such treatment does not have an injurious effect on the areas of Iosco sandy loam. Erosion by wind or water is not serious on this soil.

Ottawa fine sandy loam.—The 6- or 8-inch plow soil of Ottawa fine sandy loam consists of dark-gray or grayish-brown fine sandy loam which is medium acid in reaction, mellow, easily worked, and

free of stones or boulders. The subsoil is grayish-yellow acid fine sand or loamy fine sand to a depth ranging from 2 to 3 feet. It is slightly compact but not cemented to any extent. The substratum consists of red sandy clay or silty clay alternating with layers of brown or yellow sand. The presence of this layer is an important feature of this soil in the retention of moisture. The clayey material is neutral or slightly acid.

Ottawa fine sandy loam resembles Arenac fine sandy loam in some respects, but it has slightly better natural drainage and a less brown subsoil layer than does the Arenac soil.

Ottawa fine sandy loam is developed in sections 33 and 34 of Riverton Township in an area of only 320 acres.

This soil occurs on nearly flat old sandy lake plains that have become well enough drained that crops grow normally without the aid of artificial drainage. This soil originally was forested with pine and hardwoods, but it all has been placed under cultivation. Acre yields of corn range from 20 to 35 bushels, wheat 15 to 30 bushels, oats 25 to 50 bushels, potatoes 75 to 300 bushels, beans 5 to 15 bushels, and alfalfa 1 to 3 tons.

This soil is not especially subject to wind erosion, and can be cultivated without damage under a wide range in moisture content. It responds readily to the use of manure and commercial fertilizers. An application ranging from 2 to 5 tons of lime an acre is necessary in order to grow alfalfa successfully.

Arenac fine sandy loam.—Arenac fine sandy loam is developed from a 2- to 3-foot layer of very sandy material over impervious clay. Under virgin conditions it has a 2-inch layer of slightly acid very dark grayish-brown loam which is largely decomposed organic matter mixed with fine sand. This is underlain by a 2- to 6-inch layer of light grayish-brown or ash-gray strongly acid fine sand, and this, in turn, is underlain by a layer of yellowish-brown or brown strongly acid loamy fine sand, 8 or 10 inches thick. Below this is grayish-brown fine sand slightly mottled with rust brown and bright yellow, which is medium to strongly acid and ranges from 10 to 20 inches in thickness. At a depth ranging from 20 to 30 inches, the material consists of reddish-brown heavy calcareous silty clay, silt, and fine sand. Under cultivation the upper two layers and a part of the third layer become mixed and form a grayish-brown or dark-gray plow soil. This soil is separated from Iosco sandy loam and Ogemaw sandy loam chiefly on differences in drainage and development of the brown layer. The Ogemaw and Iosco soils either have a hardpan or the brown layer tends to be indurated or cemented, and they are not so well drained as is Arenac fine sandy loam, especially during the wetter seasons of the year. Because of their small extent, a few small areas of Arenac loamy sand, Ogemaw sandy loam, and Munuscong sandy loam are included with Arenac fine sandy loam in mapping.

Less than 4 square miles of Arenac fine sandy loam are mapped. The largest areas are those in Amber Township southwest of Scottville and in section 11 of Hamlin Township. Smaller areas are scattered over the county.

This soil occupies smoothly undulating old lake beds or plains. Natural drainage is fair or imperfect but, in most places, is sufficient for field crops and small fruits. Run-off is slow, but the upper part

of the soil is sufficiently pervious for water to penetrate readily to the clay substratum, where its further movement is retarded and slow.

This land originally was covered with a forest consisting of sugar maple, beech, hemlock, basswood, ash, elm, and cherry, but probably more than 90 percent of it has been cleared and placed under cultivation. It is used for general and truck crops, together with the raising of dairy or beef cattle. From 10 to 15 percent of the cultivated area is planted to corn which yields from 20 to 35 bushels an acre; and a similar area is planted to wheat and rye, which yield from 15 to 30 bushels and 10 to 25 bushels, respectively. Oats occupy a slightly smaller area and yield from 25 to 50 bushels an acre. Perhaps 5 percent of the land is planted to potatoes, yields of which range from 75 to 300 bushels an acre. From 20 to 30 percent of the total area is used for hay and pasture, and fair yields of alfalfa and other hay crops are obtained. String beans, cucumbers, and small fruits do well on this soil, and return a good acre income when economic conditions are favorable.

Some type of a 3- to 5-year crop rotation is practiced on most farms—clean-cultivated crops generally following sod or noncultivated crops. Barnyard manure generally is applied broadcast once or twice in the rotation, and different quantities of commercial fertilizers commonly are used with the cash crops, especially wheat which generally receives from 150 to 200 pounds an acre of 2-16-2 or 2-12-6. In general, it is necessary to use from 1 to 3 or more tons of lime an acre, in order to get a good stand of alfalfa. Fall plowing is done wherever possible, but this soil is easily managed, as it can be plowed or cultivated under a wide range of moisture conditions. It requires frequent additions of organic matter and fertilizer, in order to maintain its productivity.

SANDS AND LOAMY SANDS

Arenac loamy sand.—Arenac loamy sand has a 4- to 6-inch dark-gray or dark grayish-brown plow soil that is strongly acid and is low in organic-matter content. It contains no stones or boulders, is loose, and can be worked without harmful effects over a wide range in moisture conditions. The subsoil consists of a 4- to 8-inch layer of reddish-brown or brownish-yellow strongly acid slightly loamy sand. Beneath this is pale-yellow medium sand extending to a depth ranging from 3 to 4 feet. This sand layer is strongly acid and in the lower part is somewhat mottled with rust brown and bright yellow. Beneath the sand the material consists of sandy clay, heavy clay, or a silty layer which retards the downward movement of water.

As mapped, Arenac loamy sand includes small areas of Rubicon sand, in which the sand is deeper, and in places small areas of Saugatuck sand are included. Arenac loamy sand typically is intermediate in drainage conditions between the Kalkaska or Rubicon soils and Saugatuck sand.

Small to medium-sized areas are scattered over the central and southern parts of the county, especially in Amber Township. The total area mapped is slightly more than 10 square miles. This soil occupies undulating or nearly flat outwash plains or lake plains where a sand covering overlies the clay substratum.

The native vegetation has been largely cut, but it probably consisted of a mixed forest of pines and hardwoods. Although the

lower part of the subsoil is somewhat imperfectly drained, Arenac loamy sand does not require artificial drainage for the production of the crops commonly grown on it. It is generally farmed in connection with dairying so that large quantities of manure can be applied to the soil. About 75 percent of the land is used for crops and pasture. Acre yields of corn range from 15 to 30 bushels, beans 5 to 12 bushels, rye 5 to 20 bushels, potatoes 50 to 200 bushels, and alfalfa 1 to 2 tons. Under optimum conditions good returns from small fruits, cucumbers, and string beans are obtained. Few tree fruits are grown, as most of this soil does not have sufficient air drainage for the orchards.

Alfalfa cannot be grown without an acre application ranging from 3 to 5 tons of lime. Without heavy applications of manure, yields rapidly diminish, and soil blowing is a serious menace under continuous clean cultivation. Considerable areas of this soil undoubtedly would be abandoned, were it not for their location along good roads and close to a large town. Some farmers, whose farms are near a market, make a fair living on this soil by growing potatoes, string beans, cucumbers, other truck crops, small fruits, and apples. In order to farm this soil profitably, good management must accompany favorable economic conditions.

Arenac loamy sand, rolling phase.—Arenac loamy sand, rolling phase, occupies a broken plain where the relief ranges from undulating to sloping or gently rolling. The smoother areas have a sand or loamy sand covering, ranging from 2 to 4 feet in thickness, over clay or layers of silt, clay, and sandy clay. On many of the slopes, these clayey layers are exposed or have a covering of only a few inches of sand or loamy sand. The soil in the small included valleys has a dark-colored loamy sand or sandy loam surface soil, enriched by wash from the slopes, which may be underlain by either clay or sand. Arenac loamy sand, rolling phase, in places occupies breaks and escarpments bordering stream bottoms. Only a very small total area of this rolling soil is mapped, chiefly in section 23, Amber Township.

About two-thirds of this land is used for pasture, and the rest is used for the production of hay, corn, beans, rye, potatoes, and cucumbers. Yields of hay range from 1 to 2 tons an acre, corn 10 to 25 bushels, beans 5 to 10 bushels, rye 5 to 20 bushels, and potatoes 50 to 175 bushels. Average yields of cucumbers and string beans are obtained.

The slopes of this soil will wash or erode under clean cultivation. It is essential to rotate crops as well as to plow around the slopes with the contours.

Ottawa loamy fine sand.—The 5- or 6-inch surface soil of Ottawa loamy fine sand consists of dark-gray or dark grayish-brown acid loamy sand which is loose, mellow, somewhat low in organic matter, and easily worked. The subsoil material, which extends to a depth ranging from 15 to 20 inches, is light yellowish-brown strongly acid loamy sand. The substratum consists of yellowish-gray acid sand, with a slight mottling of bright yellow and rust brown, which grades, at a depth of about 3 feet, into less pervious reddish-brown slightly acid or neutral material composed of thin layers of clay and silt or sandy clay alternating with layers of sand. In a few places,

this underlying material is heavy impervious clay. This soil is separated from Arenac loamy sand on account of its more thorough natural drainage and the finer texture of the sand.

This soil is mapped in a few areas, most of which lie in section 11, Hamlin Township, and section 33, Riverton Township. It is developed on sandy outwash plains or sandy old lake beds where the surface is smooth and nearly flat or undulating.

Surface run-off is slow, but the loose open structure of the soil allows free penetration of water. The underlying clay layer is not near enough to the surface to impede drainage to the extent of interfering with any of the crops grown. The native vegetation consisted of forest, chiefly sugar maple, beech, and hemlock, with associated trees.

Approximately 90 percent of this soil has been cleared and placed under cultivation, but at present a part is in permanent pasture. Rye, beans, and corn are the chief field crops, and tree fruits are grown to some extent where the location of the orchards affords sufficient air drainage. Acre yields of rye range from 5 to 15 bushels, beans 3 to 15 bushels, corn 10 to 12 bushels, and potatoes 50 to 150 bushels. A large quantity of manure and commercial fertilizer is required to make this soil productive, and the shortage of moisture is a limiting factor. Under continuous clean cultivation, care must be exercised to prevent the surface soil from blowing.

Ottawa loamy fine sand, broken phase.—Ottawa loamy fine sand, broken phase, occurs along the south shore of the upper part of Hamlin Lake, where an abrupt drop, ranging from 50 to 100 feet, from the featureless plain to the lake has resulted in the cutting of numerous ravines back into the plain to form a small steep and broken area. Many slopes are in excess of 18 percent, but some have less gradient. The tops of the hills and ridges have a sand or sandy loam surface soil underlain, at a depth ranging from 2 to 4 feet, by a layer of clay or sandy clay. The soil on the slopes is extremely variable in texture, ranging from heavy clay to pure sand. The sand and sandy loam materials on the slopes are acid, but the clay and sandy clay layers generally are neutral or alkaline.

The land is forested with beech, sugar maple, hemlock, elm, ash, basswood, and other trees. This soil is used largely for resort purposes and cottage sites along Hamlin Lake.

Saugatuck sand.—Saugatuck sand is characterized by a dark-brown sandy hardpan. It has a thin surface layer of dark grayish-brown strongly acid organic matter which is fairly well decomposed in the lower part and less well decomposed above. The underlying mineral soil is light-gray or nearly white very strongly acid medium sand slightly streaked with brown, ranging from 2 to 12 inches in thickness. This is underlain by a coffee-brown or dark yellowish-brown cemented hardpan, which ranges from 6 to 18 inches in thickness and lies from 6 to 30 inches beneath the surface. Beneath the hardpan layer is dingy-gray or grayish-brown water-soaked strongly acid medium sand that continues to a depth of more than 4 feet. The hardpan layer ranges in hardness from rock to material that crumbles easily under pressure. Over large areas it is so firmly cemented that it is difficultly penetrable for roots and contains but few cracks or seams; whereas in other places the cementation is weak,

and water and roots pass through easily. Small areas of other soils mapped with areas of Saugatuck sand and in such small irregular-shaped bodies that it was impractical to separate them on the scale of mapping used, include Newton loamy sand, Rubicon sand, Wallace fine sand, and Arenac loamy sand.

The larger areas of Saugatuck sand are in Grant, Pere Marquette, Meade, Victory, and Hamlin Townships, and small areas are scattered over the entire county. Slightly more than 32 square miles are mapped.

This soil occupies old poorly drained sandy lake-bed plains where the relief is slightly undulating. Under natural conditions the water table has been, for long periods of time, just below the surface of the ground or just below the depth at which the hardpan developed. Although water seldom stands on the surface, crops cannot be grown without artificial drainage, except in the drier years.

The original vegetation consisted chiefly of white pine and red pine, but after the forest was cut and burned over a second growth sprang up consisting of quaking aspen, some white pine, red pine, and swamp oaks, with a ground cover of wintergreen, bracken, blueberries, and other herbs and shrubs.

Although all the land has been cleared of trees and burned over, only small areas have been cleared sufficiently for farming and very little remains under cultivation. Even with an expensive artificial drainage system, the soil warms slowly in the spring. Crops grown on it are susceptible to late and early frosts, and the soil is deficient in essential plant nutrients. If the ditches are deep enough to drain the soil in early summer, the soil becomes too dry in midsummer, and the hardpan prevents deep rooting, consequently crops are injured, even during short droughts.

The largest area under cultivation is along a main highway within 6 miles of Ludington. Near Lake Michigan, a more favorable climate and nearness to market have combined to produce a fairly successful agriculture on some areas of Saugatuck sand. About 10 percent of the cultivated area is planted to corn, and under the best of management it yields from 15 to 20 bushels an acre, but under ordinary cultural methods it fails, in many years, to make grain and produces only forage. Under good management fair yields of beans, rye, and potatoes are obtained in some years. Timothy and alsike clover give fair yields of hay. String beans, cucumbers, and strawberries seem to give the best cash returns of the crops grown on Saugatuck sand, and small fields are devoted to each by most farmers on this soil. Owing to the lack of nearby markets, great distances from the established markets, and the availability of better land for truck crops and small fruits, it is probable that no large areas of Saugatuck sand ever will be profitably used for other purposes than forestry, pasture, and game refuges.

POORLY DRAINED SOILS

MINERAL SOILS

Bergland loam.—Bergland loam is a heavy-textured dark-colored poorly drained soil. It has a dark-gray or nearly black surface soil, or plow soil, of heavy loam, from 4 to 8 inches thick, ranging from

slightly acid to neutral. The dark color is due largely to the high content of organic matter. This layer is underlain by a 4- to 6-inch layer of light-gray or drab slightly acid sandy loam or loam, which, at a depth ranging from 14 to 30 inches, is, in turn, underlain by light yellowish-brown sandy clay or clay, strongly streaked and mottled with rust brown and light gray. The material in the upper part of this layer is slightly acid, but it becomes alkaline at a depth ranging from 18 to 24 inches. Heavy gray, drab, or bluish-gray alkaline clay continues to a depth of several feet.

Included with areas of Bergland loam are areas which would be mapped as Bergland clay loam if their size warranted such a separation. Very small areas of Ogemaw sandy loam, Munuscong sandy loam, Otto sandy loam, Otto silt loam, Nester loam, and Selkirk silt loam also are included.

In general, Bergland loam occupies low wet areas in close association with the Nester and Selkirk soils. The relief is undulating or nearly flat, and the soil is mapped both on lake plains and on till plains, or ground moraines. Small areas are scattered over the county, chiefly in Amber, Custer, Sherman, Sheridan, and Logan Townships.

Natural drainage is poor, and, even where aided by artificial drainage, run-off is slow, owing to the slight slope of the land. Internal drainage is poor, because of the heavy texture of the underlying material. The high water table is the chief limiting factor to deep penetration of roots, as plant roots readily penetrate the clay subsoil in places where the land is well drained. Stones and boulders are not numerous on or in this soil. Originally, most of the land was forested, principally with red maple, silver maple, ash, elm, swamp oaks, basswood, and hemlock.

The areas of Bergland loam are low and subject to frost, and the crops commonly grown on them are especially susceptible to injury from late and early frosts. Therefore the range of crops is limited, and the risk involved in attempting to grow them is increased. About two-thirds of the total area has been cleared, and slightly more than one-half of this is used for hay and pasture. Although high in natural fertility, this soil is not used extensively for cultivated crops, owing to the cost and difficulty of draining the land, in addition to the danger from frosts. In places where artificial drainage has been provided, acre yields of corn range from 25 to 40 bushels; beans, 5 to 15 bushels; oats, 30 to 60 bushels; wheat, 15 to 35 bushels; rye, 15 to 25 bushels; and alfalfa, 1 to 4 tons. Generally potatoes are not grown on this soil, but many small areas are devoted to small fruits, string beans, and cucumbers, as supplementary cash crops.

Small areas of the Otto and Ogemaw soils included and associated with Bergland loam require applications of manure and fertilizer, in order to maintain the productivity of the land as a whole. In most places it is not necessary to lime Bergland loam, but the included spots of other soils require lime for the production of alfalfa, and the common practice is to lime the entire field. Considerable care must be exercised to not work this soil when too wet, as it will puddle and become hard and difficult to handle or work for some years to follow. Occasional green-manure crops or applications of barnyard manure are needed in maintaining the productiveness of this soil. The

method of drainage used is a system of open ditches, but a more complete drainage system, with the use of tile, would improve the productiveness of the land.

Otto sandy loam.—Otto sandy loam has a surface, or plow, soil of light-colored sandy loam, which has developed under poor drainage and is strongly acid. Normally, under cultivation, it consists of a 4- or 5-inch layer of gray or light-gray sandy loam, which is strongly acid and low in organic matter, underlain by a 6- or 8-inch layer of nearly white sand or loamy fine sand, which also is strongly acid. Below a depth of about 15 inches, layers of reddish-brown light sandy clay, 2 or 3 inches thick, alternate with layers of light-gray sand. The material in this layer is strongly acid to a depth ranging from 3 to 4 feet.

As mapped, this soil includes many small areas having dark-colored surface soils throughout the large areas. This is owing to the complex association of light- and dark-colored soils. Thin layers of clay at or near the surface are common, but are of indefinite extent, and they also are included. In places till clay or lacustrine clay is at a depth ranging from 30 to 40 inches beneath the surface, and a few small spots having brown sand hardpanlike layers also are included in areas mapped as Otto sandy loam.

Otto sandy loam is associated closely with Otto silt loam, Bergland loam, and Munuscong sandy loam, and it occupies similar positions on smooth undulating or nearly flat poorly drained lake plains. Both internal and external drainage are poor and slow. The soil occurs mainly in Sherman Township, and scattered small bodies are in the south-central part of the county.

The native vegetation consisted of a dense stand of elm, soft maple, hemlock, black ash, and associated trees. The crops grown on this soil have a slightly wider range than those grown on Otto silt loam and other silt loam or loam soils. Grains, field beans, string beans, cucumbers, corn, potatoes, and hay are widely grown. About 5 percent of the total area is planted to potatoes which yield from 100 to 300 bushels an acre, depending greatly on frost conditions. About 10 percent of the total area is devoted to each of the following crops: Corn, oats, wheat or rye, and beans; and the rest is used for hay and pasture. Acre yields of beans range from 5 to 15 bushels, corn 15 to 25 bushels, oats 25 to 40 bushels, and wheat 15 to 25 bushels.

Management of this soil is similar to that practiced on the other poorly drained sandy loam soils, except that larger quantities of lime and organic matter are needed, in order to insure the best possible yields.

Artificial drainage is by means of open ditches, but most areas of this soil have not been provided with optimum drainage. Lateness of planting during wet seasons, owing to slow drainage, is a limiting factor in crop yields.

Otto silt loam.—Otto silt loam is a poorly drained heavy-textured soil with a light-colored strongly acid plow soil. In cultivated areas the surface soil is light-gray or gray silt loam with a fine-granular structure, and it is low in organic matter. This soil is hard to work, owing to its heavy texture. Beneath the plow soil, the material grades into the subsoil consisting of medium or strongly acid light yellowish-brown heavy silty clay mottled with rust brown and light

gray. The subsoil material is plastic and sticky when wet but when dry crumbles into small blocks less than 1 inch in diameter. At a depth ranging from 14 to 30 inches, the lower part of the subsoil consists of light grayish-brown silty clay, mottled with light gray and rust brown, and it is alkaline in reaction. When dry or moist this material breaks into prismatic-shaped lumps, about 2 inches long, which have a brown coating. The substratum, below a depth of about 30 inches, is light-brown or grayish-yellow fine sand and silt, with layers of clay lacustrine material. The material is slightly acid, neutral, or slightly alkaline.

This soil contains a few small stones, but they are not sufficiently numerous to interfere with cultivation. The organic-matter content under forest conditions is low and under cultivation soon becomes depleted. Although the clay is heavy and dense, it contains sufficient cracks and seams so that roots penetrate it. Small areas included with this soil in mapping have a very dark gray or black surface soil and would be mapped as Bergland soils if they were sufficiently large. Small dark-colored areas of Munuscong sandy loam also are included. The distinguishing features of Otto silt loam are a light-colored silt loam or loam surface soil, which is acid or strongly acid in reaction, poor natural drainage, and a heavy impervious clay subsoil.

The total area of this soil is not large. The principal areas are northeast of Scottville and southwest of Fountain in Sherman Township.

The relief ranges from nearly flat to slightly undulating. This soil occupies old lake beds. External drainage is poor or imperfect, and internal drainage is poor and slow. This soil originally was forested with a dense stand of sugar maple, beech, ash, elm, basswood, hemlock, silver maple, red maple, yellow birch, ironwood, and probably a few white pine. More than 90 percent of the land is cleared, artificially drained, placed under cultivation, and used chiefly in a system of grain and livestock farming. Corn, wheat, oats, and beans each occupy about 10 percent of the land, and the rest is used for hay and pasture. Without artificial drainage, this soil is practically limited to use as hay and pasture land. By the time the soil becomes sufficiently dry to plow and plant without artificial drainage it is too late for grain, corn, or beans to mature. All the land has been partly drained by artificial means, but little, if any, of it is adequately drained for the maximum yields.

Considerable quantities of barnyard manure are applied to the soil during the usual 3- to 5-year rotation. Commercial fertilizers generally are applied on wheatland at the rate of 125 to 200 pounds an acre of 16- or 20-percent superphosphate, 2-12-6, or 2-16-2, and under such treatment wheat yields from 15 to 30 bushels an acre. Ordinarily the other crops in the rotation receive no commercial fertilizer, with the exception of oats which sometimes receive from 75 to 125 pounds of one of the above-mentioned commercial fertilizers. Yields of oats range from 25 to 60 bushels an acre, corn 10 to 25 bushels, beans 5 to 12 bushels, and hay 1 to 3 tons, the latter depending largely on the kind of hay crop grown and the seasonal conditions.

Otto silt loam requires very careful management in order to build it up to a productive state and to maintain that productivity. Additional quantities of organic matter, above that provided in the virgin soil, are needed. This is best supplied by the plowing under of green and barnyard manures. This practice also helps to loosen the tight structure of the soil, so that it can be worked more easily. In order to obtain a stand of sweetclover, the best green-manure crop for a heavy soil, the application of lime in some form is necessary. Artificial drainage is provided by open ditches, and as a result it is difficult to provide sufficient surface drainage without seriously affecting working conditions in a field. Tile drains apparently are not used. If surface run-off as well as internal drainage could be speeded, so that the soil could be worked earlier in the spring, crop yields would be increased and injury from early frosts reduced. The danger of early frosts on this soil is a limiting factor in the range of crops that can be successfully grown, compared to those grown on higher lying soils.

Munuscong sandy loam.—The surface soil, or plow soil, of Munuscong sandy loam is dark grayish-brown or very dark gray sandy loam or fine sandy loam, 6 or 8 inches thick. It is loose, slightly granular, dark colored (owing to a high organic-matter content), and ranges from neutral to slightly acid in reaction. The subsoil, ranging from 12 to 36 inches in thickness, consists of dingy-gray loamy sand or sandy loam, which is slightly acid. This layer varies in color from place to place, even in the same field, ranging from dingy gray to dark grayish brown, strongly mottled with reddish brown and bright yellow. It is abruptly underlain by an impervious layer which consists of gray heavy silty clay or sandy clay (locally called "blue clay"), which is mottled with rust brown, yellow, and red. The reaction of this material ranges from neutral to alkaline.

This soil is intermediate in texture between Bergland loam and Newton sand or Granby sandy loam, and it includes small areas of Bergland loam and of Ogemaw sandy loam, that were too small to map separately. It is closely associated with the Ogemaw, Iosco, Nester, and Selkirk soils in scattered small areas ranging in size from less than 1 acre to 400 acres. The largest bodies are in the southern parts of Summit and Riverton Townships, and in Eden, Amber, Custer, Victory, and Sherman Townships. The total area is 6.9 square miles.

This soil occupies low-lying lake-bed plains and low pockets in moraine and till-plain areas. The bodies are nearly flat, although they occur in places on the lower slopes where the gradient is as much as 7 percent. Surface run-off is slow, and internal drainage is poor, because the clay substratum prevents the water from draining away. The native forest cover consisted of a mixed stand of soft maple, elm, swamp oaks, beech, ash, hemlock, and a few white pine and arborvitae.

Probably less than one-fourth of this soil has been cleared and partly drained artificially. Owing to its low position, crops are subjected to late and early frosts, therefore frost-resistant crops or varieties of crops are necessary. As considerable risk from frosts is involved in the growing of corn, beans, and potatoes, the use of this land is restricted largely to grains, hay, and pasture, because these crops are more tolerant of the poor drainage. Timothy and alsike clover are the main hay crops, and they return good yields. Oats also give fair

yields, ranging from 25 to 50 bushels an acre. Some areas have been sufficiently well drained that corn and potatoes yield from 20 to 35 bushels and 100 to 300 bushels an acre, respectively, in years when early frosts do not take place before these crops mature. Probably 75 percent of the land is pastured or is in woodland.

The chief limiting factors to the more extensive use of Munuscong sandy loam apparently are the cost of drainage and the lack of a frost-resistant cash crop. The natural fertility is high, and the soil is easily tilled when drained. The land can be worked over a wide range in moisture content without harmful effect.

The present artificial drainage is by means of open ditches, most of which are shallow and are clogged readily by brush, weeds, and grass. Outlets into the main streams are generally expensive, owing to the necessity of dredging long ditches.

Granby sandy loam.—The 4- to 6-inch surface soil of Granby sandy loam consists of dark-gray or dark grayish-brown sandy loam, which is a mixture of organic matter and gray sand, ranging from very slightly acid to slightly alkaline. The subsoil of medium sand and fine sand extends to a depth of 4 feet or more. It ranges in color from grayish white to dingy gray, mottled with rust brown. This soil differs from Newton loamy sand in that it has a heavier surface soil, or plow soil, and is neutral or alkaline in reaction instead of acid. A few small spots of Saugatuck sand are included in mapping.

This soil occurs principally in three areas—one northwest of Fountain, one south of Scottville, and the third in the southwestern corner of Riverton Township.

Granby sandy loam occupies low nearly flat old lake beds. Natural drainage is poor, and water remains near the surface most of the year unless the land is drained artificially. The native cover consisted of a hardwood-swamp vegetation with elm, red maple, silver maple, and black ash as the dominant trees. About one-half of this soil has been cleared and sufficiently drained for the production of corn, beans, small grains, and hay. It is subject to early and late frosts, and the maturity of potatoes, corn, and beans before early fall frosts is uncertain. The natural fertility is rapidly depleted under cultivation; consequently, programs for soil improvement are necessary, in order to maintain crop yields. Under optimum rainfall and frost-free conditions, acre yields of corn range from 15 to 30 bushels, beans 5 to 10 bushels, potatoes 50 to 150 bushels, oats 20 to 30 bushels, rye 10 to 20 bushels, and timothy and alsike hay 1 to 2 tons. String beans, cucumbers, and small fruits do well on this soil under optimum frost conditions, if soil fertility is maintained.

Care must be exercised not to overdrain this soil, as it then becomes too dry and, as in the dry sands, lack of moisture becomes the chief handicap to plant growth. When too dry and under clean cultivation, the surface soil blows readily in the wind. Artificial drainage is entirely through open ditches.

Newton loamy sand.—Under virgin conditions, Newton loamy sand has a 1- or 2-inch layer of dark grayish-brown or nearly black slightly acid fairly well decomposed organic matter underlain by a 2- to 4-inch layer of gray strongly acid medium sand stained slightly brown in streaks by organic compounds. Below this is gray or grayish-yellow sand, mottled or splotted with brown and bright yellow,

which is medium acid to strongly acid in reaction. Included with mapped areas of Newton loamy sand are small areas of Saugatuck sand.

The total area of Newton loamy sand is 18 square miles. Fairly large bodies are in Grant, Hamlin, Victory, and Meade Townships, and smaller areas are scattered throughout the county. The relief ranges from nearly flat or level to slightly undulating. This soil is developed on old sandy lake beds, under a high water table. Water either stands on the surface or remains near the surface much of the year, and field crops cannot be grown without artificial drainage.

Most of the areas of Newton loamy sand were forested, but in a few areas the soil has developed under marsh grasses. The present cover on the forested areas consists of arborvitae, quaking aspen, black ash, elm, soft maple, alder, hemlock, and a few white pine. Poplar, alder, and willow are the predominant trees in places where the land has been cut-over, but white pine probably was the dominant tree in the original forest.

Probably less than 10 percent of the total area has been cleared, and at present it is used chiefly for native-grass hay and for pasture. The low position of the land renders the growing crops susceptible to injury from late and early frosts. Clearing and drainage are expensive, and this soil is low in some of the essential plant nutrients. Its chief value is for game cover and for pasture.

Griffin sandy loam.—Griffin sandy loam is the mineral soil of the stream bottoms. It has a 6- to 8-inch layer of dark grayish-brown or very dark gray sandy loam that, in most places, is high in organic matter and ranges from strongly acid to neutral in reaction. This is underlain by a 10- to 20-inch layer of drab or grayish-brown sandy loam mottled with yellow and rust brown; and this, in turn, by various-textured materials consisting of layers of coarse sand, sand, silt, and clay. In places where considerable quantities of recent alluvium have been deposited, the material may consist of layers of yellow or yellowish-brown fine sand and medium sand to various depths. This soil is variable, ranging from areas of nearly pure sand to areas of silty clay loam or muck. The different variations are of such small extent and the boundaries so irregular that their separation seemed inadvisable in mapping the narrow strips of bottom land.

Griffin sandy loam occurs along the main streams of the county. These bottoms are subject to overflow although they seldom are flooded during the summer. Most of the areas are so low, compared with the average level of the stream, that drainage is uncertain without dikes and pumps.

Most of this land is forested with elm, black ash, arborvitae, swamp oaks, red maple, silver maple, and a few white pine or spruce, as well as a few other trees and bushes. The native vegetation on a few small areas is grass, and some such areas are used for gardens and forage crops. Most of this soil, however, is in pasture, wood lots, or remains as waste land. Excellent pasture is afforded in places where the land is not too low and wet and not too thickly grown up to brush and trees.

Maumee loam.—The surface soil of Maumee loam consists of a 6- to 12-inch layer of a loamy mixture of very dark brown organic

matter and gray sand, which in most places is slightly acid. The subsoil is gray wet sand extending to a depth of several feet. In places areas mapped as Maumee loam have a 10- to 14-inch layer of nearly pure organic matter over gray wet sand. This organic, or muck, layer consists of well-decomposed wood and grass and generally is slightly acid.

Maumee loam occurs principally in two small bodies in sections 23 and 25 of Summit Township.

The areas of this soil are very nearly flat, and the water table is only a few inches beneath the surface much of the year. It would be necessary to drain this soil artificially as well as to clear it of brush and stands of elm, ash, soft maple, arborvitae, and other swamp trees before it could be cultivated. Some areas support a grass cover and are pastured. Cleared or cut-over areas provide excellent pasturage. The low position would subject crops to frost damage; therefore, little or none of this land is under cultivation.

Wallkill loam.—Wallkill loam occupies pot holes or depressions where mineral soil has washed into and over a deposit of muck or peat. In places it consists of a 6- or 8-inch layer of dark-gray or black loam or clay loam, composed of wash from the surrounding hills, overlying black or dark-brown muck 2 feet or more thick; elsewhere the topmost 6- or 12-inch layer is a mixture of mineral material and muck or peat. Areas ranging in size from 1 acre to 5 acres are scattered over much of the county. The largest of these small areas is in section 8 of Riverton Township. A total of less than 1 square mile is mapped.

This soil occupies old pond or lake beds. Owing to the poor natural drainage and the difficulty of establishing artificial drainage, these areas are used for pasture or are left as waste land or used for water reservoirs. The soil has high potential productivity, but it occupies positions subject to frost.

ORGANIC SOILS

Lupton muck.—Lupton muck consists of a 6- to 8-inch layer of very dark brown or black well-decomposed alkaline to slightly acid granular organic matter matted together with roots, underlain by dark-brown finely divided well-decomposed organic matter which continues to a depth of 2 or 3 feet. Many partly disintegrated pieces of wood, as well as entire tree trunks and roots, occur in this layer. The material ranges from neutral to slightly acid. Below a depth ranging from 2 to 3 feet is black or dark-brown finely divided sedimentary peat and muck, which are neutral or alkaline in reaction.

A large area of this muck is in the south-central part of the county along the Oceana County line; fairly large areas are in Eden, Sheridan, and Sherman Townships; and small areas are scattered over the rest of the county. It covers a total area of 17.4 square miles.

Possibly 20 percent of this soil has been cleared sufficiently to be used as pasture land, and it provides excellent pasturage when the brush is kept down. Possibly 10 percent of the total area is cleared and is being farmed. The land requires artificial drainage before it can be successfully farmed, and large areas require ditches, with

dams to control the water table so as not to overdrain or lower the water table too much. The land is moderately fertile, but it is very susceptible to frost. Corn seldom ripens between the latest and earliest frosts, but a large tonnage of corn for forage can be grown successfully. Under proper management, good yields of timothy and alsike hay can be obtained, and barley yields from 20 to 40 bushels an acre. Oats and wheat generally are not grown.

If this muck is overdrained, deficiency in moisture becomes the chief limiting factor in plant growth. Dry muck readily drifts about in the wind, causing considerable loss and damage. A few small areas are devoted to truck crops, mainly for home consumption. Commercial production should be practical on the more favorably located tracts.

Houghton muck.—The surface soil of Houghton muck consists of a 6- or 8-inch layer of brown or nearly black fibrous loose granular well-decomposed organic matter matted together with roots. It ranges from neutral to slightly acid in reaction. Beneath this is a mixture of brown or black fibrous fairly well decomposed remains of grasses, sedges, and other marsh vegetation. This material also is neutral or alkaline in reaction. The total depth of this type of muck ranges from 2 to more than 20 feet.

Houghton muck is mapped in scattered small areas throughout the county. One of the larger areas borders Lincoln Lake north of Ludington, and one is east of Ford Lake. This muck occupies old lake beds and has developed under a cover of reeds, sedges, cattails, grasses, and other nonwoody water-loving vegetation. The height of the water table ranges from the surface to 20 inches below.

Practically none of this land is cultivated, in spite of its high natural fertility. Its low position, susceptibility to early and late frosts, and the difficulty of controlling the water table discourage its use for farming. It is pastured in many places, and in a few places the native grasses are cut for hay.

Rifle peat.—The surface layer of Rifle peat consists of brown or dark-brown nearly pure organic matter made up of partly decomposed and well-decomposed woody and leafy materials. This layer in general is slightly acid. At a depth ranging from 6 to 12 inches, it grades into brown less well decomposed fibrous acid material derived more from a water or marsh type of vegetation than from woody material. This type of organic material ranges in thickness from 3 to more than 30 feet. Large areas are developed along Big Sable River on the Lake County boundary, east of Ford Lake in Sheridan Township, and east of Gooseneck Lake in Branch Township. Smaller areas occur in other parts of the county. A total of 10.3 square miles is mapped. Rifle peat represents an older stage in the filling of lakes than does Greenwood peat. The water table in most places is about 12 inches beneath the surface.

This type of peat supports a dense stand of *American arborvitae* (northern white cedar), tamarack, black spruce, and a few white pine, together with other swamp shrubs and sedges. A few small areas have been cut-over and sufficiently cleared to provide good pasture, but much of the land supports too dense a growth of trees and brush to provide pasture. It produces fence posts and poles for telegraph

and power lines, as well as affording a good cover for game and reservoirs for the storage of water.

Burned muck over clay.—Burned muck over clay, as the name implies, includes land where the muck or peat has been burned, and the material now consists of a 1- to 3- foot layer of mucky organic matter and ashes over heavy compact impervious clay. The mucky surface soil in most places is neutral or slightly alkaline, and the underlying clay is alkaline in reaction.

Only 64 acres of this type of muck soil are mapped. It occurs principally in one area west of Round Lake in Sheridan Township. It occupies nearly flat areas in the beds of old lakes or ponds, where natural drainage was poor and some artificial drainage preceded the burning.

At present this land is pastured, but eventually it will become similar to Bergland loam and will have the same potential uses as that soil.

Greenwood peat.—Greenwood peat consists of a 6- or 8-inch layer of brown or yellowish-brown coarse fibrous raw peat which is almost pure organic matter and is very strongly acid. The underlying material is very strongly acid finely divided peat composed of reed, sedge, and aquatic plant materials forming a spongelike mat. The thickness of the deposits of Greenwood peat range from 3 to more than 30 feet. This peat is so acid that ordinary field crops and most deciduous trees will not tolerate it. It is chiefly covered by a low bush, called leatherleaf, from 2 to 3 feet high, which forms a dense cover. A few aspen, willow, tamarack, and black spruce trees also grow on this land.

It occupies scattered areas over the county in old lakes which have been entirely filled by plant remains, and a few lakes throughout the county are nearly filled with this type of peat. In some places, now grown over, local residents can remember when a lake still existed. Some of the larger areas are in the western part of Eden Township.

Greenwood peat is not suited to any field crop now grown in the county and should not be cleared for ordinary agricultural use. This is the type of peat described in United States Department of Agriculture Farmers' Bulletin 1400 (1) as being suitable for cranberry culture, where other conditions are favorable.

Burned muck over sand.—Burned muck over sand is mapped in areas where the muck or peat deposits underlain by sand have been burned. In most places it consists of a 12- to 24-inch layer of black organic matter mixed with brown and gray ashes over gray acid sand. The residue from burning generally is neutral or alkaline.

The largest area is in the southeastern part of Eden Township. A few small areas are mapped elsewhere. The relief is very nearly flat, as this type of muck occupies old lake beds. The land is naturally wet and poorly drained, and the burning is the result, for the most part, of overdraining and clearing operations.

The original vegetation on the largest area of burned muck over sand consisted chiefly of a dense stand of large white pine, as evidenced by the stumps which withstood the burning of the 18- to 36-inch layer of muck that surrounded them. This land is now

used largely for pasture, although a few fields have been cleared and planted to corn and tame hay. Alsike clover, timothy, and sweetclover return good yields of hay and provide excellent pasture. The smooth uniform surface affords easily tilled fields.

The low position of this land makes it subject to frost, and the crops grown should be those that resist late or early frosts. As in areas of all organic soils, the water table must be controlled, and this requires an expensive system of ditches and dams. This expense, together with the expense of clearing and the uncertainty of growing cash crops, tends to keep most of this type of land in pasture.

Kerston muck.—Kerston muck is a stream-bottom or alluvial soil composed chiefly of organic matter or muck. In some places it consists of muck or peat with mineral matter mixed through it, and in other places it consists of nearly pure organic matter resembling Lupton muck or Rifle peat, but which is included with Kerston muck on account of its position along streams.

Kerston muck ranges from neutral to slightly acid in reaction. In many places a narrow strip of mineral soil adjoins the stream channel, but the greater part of the bottom is composed largely of organic material. In some places where the area is small, the strips of mineral alluvium are included in mapping with Kerston muck. Areas mapped as Kerston muck occur chiefly along Pere Marquette River and, to less extent, along Big Sable River near their mouths. A total area of 8.3 square miles is mapped.

This type of muck is subject to overflow and is too wet for cultivation without drainage by dikes and pumping in most places. Most of the land supports a forest cover of arborvitae, soft maple, elm, ash, poplar, swamp oaks, and other swamp plants, but a few areas support a marsh type of vegetation consisting of reeds, rushes, sedges, and grasses.

About 1 square mile of this land at the head of Pere Marquette Lake is used for the cutting of wild- and tame-grass hay, and the rest, with the exception of a few small garden spots, is pastured or is left in forest.

MISCELLANEOUS LAND TYPES

Coastal beach.—The low wave-washed area between the low-water mark of Lake Michigan and the lower line of the ridge of sand which marks the first rise of land inland is designated coastal beach. The area of coastal beach is broken by the harbor of Ludington and the mouths of Big Sable and Lincoln Rivers. The descent into deep water is very gradual; in most places the water is only 4 feet deep at a distance of 100 yards or more from the shore. Dangerous undertows are uncommon, and the area affords an excellent bathing beach 24 miles long.

Lake bluff.—Lake bluff is a land type which marks the abrupt break from the high morainic area in Summit Township to coastal beach bordering Lake Michigan. The local differences in elevation range from 50 to slightly more than 200 feet. Very little soil has been developed on the steep slopes, because of erosion and landslides. Along the foot of the bluff is a narrow strip of woodland composed of cedar, elm, birch, pine, and other species of trees, but

the steep slopes have only a few bushes or clumps of grasses growing on them. They are for the most part bare sand, clay, gravel, and boulders.

Made land.—Made land is mapped in places in Ludington, where ravines and low marshy places along Pere Marquette Lake have been filled in and graded with sand and other materials from building and road sites. It has no agricultural value, as it is utilized entirely for commercial purposes.

Gravel pits.—Gravel pits consist of open excavations from which gravel has been obtained for building construction, roads, and other commercial uses.

LAND USES AND AGRICULTURAL METHODS

The soils of Mason County best adapted to the crops commonly grown are, as a rule, low in organic matter. The addition of considerable quantities of organic matter in the form of green manure or barnyard manure plowed under are essential to continued normal crop yields, and, to increase the normal yields, commercial fertilizers are necessary to supplement the green and barnyard manures. One of the best methods of increasing the nitrogen content of soils, as well as the organic-matter content, is the growing and plowing under of sweetclover and alfalfa. It is generally advisable to make an acre application of 1 or 2 tons of some form of lime on the loam and silt loam soils before seeding to sweetclover or alfalfa, and heavier applications generally are required on the sandy loam soils. It is impractical to attempt to grow alfalfa on the sand soils, such as Rubicon, Grayling, Roselawn, and Saugatuck sands.

The Selkirk, Kent, and Bergland soils, in general, are hard to plow and work, and the best known treatment for them is to plow under a heavy growth of sweetclover which readily loosens the tight soil structure. Another cause of short yields on these soils and on some of the Nester soils, is the slowness of drying sufficiently in the spring for the preparation of a good seedbed and still enable the crops to be planted at the proper date. Fall plowing will in some measure help in overcoming this difficulty and make less work during the spring. Fall plowing of heavy soils also produces beneficial effects on soil structure. Shallow fall plowing and deeper spring plowing are considered good practices for the control of quack-grass which probably is the most troublesome weed pest in this county.

Improved drainage conditions would greatly facilitate tillage operations, result in better tilth in the loam and silt loam soils, and improve the yields and quality of crops. A system of tile drains, to supplement the present open drainage ditches and empty into the open ditches and streams, would be advantageous in farming operations. The open ditch itself removes from cultivation the space it occupies and divides a large field into small sections; or, if shallow enough to work across, is not deep enough to give beneficial subsoil drainage. The ditches also frequently become clogged with dirt, brush, weeds, and grass, and they require cleaning to insure effective operation.

Some form of crop rotation is practiced on most farms throughout the county, with cultivated crops alternating with noncultivated crops. A field is seldom planted to the same crop 2 years in succession, with the exception of alfalfa which commonly is allowed to remain several years before being plowed under.

The heavier soils—the loams and silt loams—which are well drained, limed when needed, and have good seedbed preparation, respond readily to applications of high-grade commercial fertilizers. Acre applications recommended for important crops (5) are as follows: For wheat or rye, from 200 to 250 pounds of 4-16-4 or 0-20-0; oats or barley, 150 to 250 pounds of 2-12-6, 4-16-4, or 0-20-0; where clover or alfalfa is to be seeded with grain, the fertilizer should be increased by 50 to 100 pounds; alfalfa, 150 to 200 pounds of 0-14-6 or 0-20-0 when seeded, and repeated every 2 years not plowed; corn, 100 to 150 pounds of 2-14-4 or 0-20-0; and potatoes, 300 to 500 pounds of 4-16-4 or 0-20-0.

Studies on fertilization, carried on in the Upper Peninsula (9), show that acre applications ranging from 300 to 400 pounds of 10-10-5 or 10-6-4 fertilizer on timothy meadows resulted in greatly increased yields and quality of hay obtained on good sandy loam and silt loam soils.

The heavier textured soils are low in organic matter; the sand, loamy sand, and sandy loam soils, still lower; and the supply must be built up if profitable yields of crops are to be obtained. Probably the best green-manure crop for light dry soils, on which it is difficult to obtain a stand of sweetclover or other legumes, is rye and vetch. Rye either can be plowed under when green or can be disked into the ground after it ripens, thus reseeding itself for the next year. It is, however, of doubtful economy to attempt to cultivate soils too low in plant nutrients and moisture-holding capacity to produce sweetclover and other more valuable soil-improvement crops. All possible organic matter of all kinds must be returned to such soils if crop yields are to be continued or increased. The most valuable soil-building material for these soils probably is barnyard manure, but large applications of 10 or more tons an acre are needed in a 3- to 5-year rotation. The burning of any crop residue should not be resorted to, as a rule, but all such residues should be plowed under.

Lime should be applied to these light-textured soils, as the best returns cannot be obtained from applications of fertilizer alone on acid to strongly acid soils. Acre applications ranging from 125 to 200 pounds of 4-16-8, or 2-12-6 commercial fertilizer (5) should be used with corn, placing the fertilizer beside the seed. Wheat should have from 200 to 300 pounds of 2-12-6 or 4-16-8 commercial fertilizer applied with the seed and a top dressing of 75 to 150 pounds of nitrate of soda or sulphate of ammonia in the spring.

It is also a good plan to plow under the wheat stubble, and seed the land to rye in August or September to be plowed under in the spring. Acre applications ranging from 200 to 300 pounds of 0-8-24, 0-12-12, or 0-20-20 are advisable before seeding alfalfa or sweetclover.

Fertilizer recommendations for potatoes call for from 400 to 500 pounds of 4-16-8 or 3-12-12 an acre, placed at the sides of the seed and slightly away from it.

The data given in table 6, from the Michigan Agricultural Experiment Station Special Bulletin 133 (4), shows definite reason for heavy applications of fertilizer as well as for returning all possible crop residues to the soil.

TABLE 6.—Quantities of plant nutrients removed from 1 acre of average farm land in Michigan and contained in several farm products

Crop	Yield	Nitrogen	Phosphoric acid	Potash	Calcium	Magnesium
		Pounds	Pounds	Pounds	Pounds	Pounds
Wheat.....	25 bushels grain.....	42.5	16.6	21.0	5.84	3.48
	2,500 pounds straw.....					
Corn.....	50 bushels grain.....	78.4	27.6	55.2	14.60	5.59
	Stover, cobs.....					
Oats.....	50 bushels grain.....	48.0	18.0	40.8	9.10	5.42
	2,500 pounds straw.....					
Rye.....	20 bushels grain.....	29.1	15.8	23.7	4.85	2.74
	2,000 pounds straw.....					
Beans.....	25 bushels seed.....	88.0	24.0	57.5		
	2,000 pounds straw.....					
Alfalfa.....	3 tons.....	147.0	30.0	126.0	83.50	21.30
Potatoes.....	150 bushels.....	31.5	13.5	45.0	1.80	2.70
Timothy.....	2 tons.....	50.0	22.0	40.0	7.11	4.08
Clover hay.....	2 tons.....	84.0	20.0	80.0	45.70	10.80

Compare the above amounts of plant nutrients in each crop with the total available plant nutrients in 200 pounds of 4-16-8 which contains 8 pounds of nitrogen, 32 pounds of phosphoric acid, and 16 pounds of potash. Studies carried on by the Michigan Station for corn, wheat, oats, rye, barley, beans, buckwheat, sugar beets, apples, peaches, pears, cabbage, onions, potatoes, mixed hay, and alfalfa, show that, of the plant nutrients removed from the soil, about one-half of the nitrogen is returned in manure, less than one-half of the phosphoric acid is returned, and about one-half of the potash is returned. The above data and studies by the station show that manure must be supplemented with commercial fertilizers if the supply of nutrients in the soil is to be maintained.

Special bulletin 248 (2), on the methods of management of sandy soils, recommends that tillage operations on the sands and loamy sands be carried on to compact the soil as much as possible and reduce aeration and decay of organic matter. Plowing should be done only to cover sod, manure, straw, or other crop residues or to control weeds. Sand or loamy sand soils should not be plowed in the fall and left bare over winter. Sloping or hilly land washes more readily during the winter if plowed in the fall. Light-textured soils should be kept covered by growing plants whenever possible, in order to utilize plant nutrients as they become available and to prevent their leaching. The cover crop then can be plowed under to be utilized for the production of crops. Firmness and compactness of the plow soil are considered the main requirements for a good seed-bed. Compactness increases the moisture-holding capacity and prevents rapid dissipation of organic matter in sand and loamy sand soils. A heavy roller of the cultipacker type is best for use on light soils.

Corn, potatoes, beans, and other intertilled crops should be cultivated only enough to eliminate weeds on these light-textured soils.

No advantage arises in the way of moisture conservation or in the production of available plant nutrients through repeated cultivation. With weeds kept out, a sandy soil will retain as much moisture and produce as much available plant nutrients where left unstirred as it will where cultivated.

Crop varieties recommended by the Michigan Station as those most adapted to the climate and mineral soils of Michigan are as follows: Hardigan and Grimm are the two most hardy and best producing varieties of alfalfa. Spartan and Glabron are the best producing varieties of barley, with Wisconsin Pedigree No. 38 probably nearly equal to the other two. The best yielding white navy bean is the Michigan Robust variety. The best adapted corn varieties are Golden Glow and Pickett Yellow Dent, with Northwestern Dent and Wisconsin No. 25 recommended for the extreme eastern part of the county. The recommended oat varieties are Wolverine, Worthy, and Markton, the latter being more smut-resistant than the other two. Recommended late potato varieties are Russet Rural, Green Mountain, and Russet Burbank, and the early varieties considered best are Irish Cobbler and Bliss Triumph. Wheat varieties best adapted to Michigan conditions are Red Rock, Berkeley Rock, Baldrock, and American Banner (8).

Paul M. Harmer, muck specialist, Michigan State College of Agriculture (3) recommends that on muck or peat, bluegrass (junegrass) pasture should receive 100 pounds of 0-8-24 fertilizer each year, in order to obtain the best quality of pasture. A mixture of timothy, alsike clover, and Dutch white clover makes excellent permanent pasture on well-drained muck land. On wet muck land, reed canary grass makes an excellent pasture or hay crop, as it can endure flooding without injury. Sudan grass and sweetclover both give fairly satisfactory results as emergency hay and pasture crops on well-drained muck land, and on wet muck, reed canary grass will provide emergency hay and pasture. Proper fertilization, together with the selection of varieties which are developed for stiffness of straw, largely solves the problem of lodging of grains. Peatland barley, especially developed for muck and peat soils in Minnesota, is the best variety for muck soils; Rosen is the best variety of rye for muck soils; Gopher and Iowar have proved the best oat varieties for peat and muck soils; of corn varieties, Wisconsin No. 25 gives the best yields of grain on mucks and peats, and any commonly grown corn varieties are acceptable for silage. The production of root crops on mucks for livestock feed often is profitable in the absence of a silo or when grown too far north in the State for the successful maturing of corn. Either carrots, mangels, or rutabagas may be grown.

For general crops on muck soils, drainage should be controlled, in order to maintain the water level at a depth ranging from 30 to 36 inches beneath the surface during the summer. Muck soil should be compacted with a heavy roller.

Oats and barley should receive an acre application ranging from 250 to 400 pounds of 0-8-24 or 0-12-20 fertilizer (5), and from 200 to 350 pounds is recommended for Rosen rye. For field corn, from 250 to 500 pounds of 0-8-24 or 0-10-20 is advised. As much

as 200 pounds may be applied in the row, preferably 2 inches below the seed, and the rest must be broadcast and worked into the muck. Timothy and alsike clover should receive from 200 to 350 pounds of 0-8-24, and sweetclover should receive a like application. Reed canary grass requires from 300 to 400 pounds of the same mixture. For recommendations for other crops see bulletin cited (5). None of the above statements is applicable to Greenwood peat.

The following bulletins giving information on soils and fertilizers may be obtained from the Soils Department, Michigan State College, East Lansing, Mich.:

Special Bulletins 133 (revised), Fertilizers—What They are and How to Use Them; 91 (revised), Lime for Sour Soils; 180, The Soils of Michigan—Grayling Sand; 248, Sandy Soils—Methods of Management; 225, Marl—Its Formation, Excavation, and Use; Circular Bulletins 90, Cucumber Culture; 103 (revised), Prevention of Wind Injury to Crops on Muck Land; and Extension Bulletins 123, Muck Soil Management for Onion Production; and 159, Fertilizer Recommendations for 1936.

PRODUCTIVITY RATINGS

The soils of Mason County are rated in table 7 according to their productivity for the more important crops. The soil types and phases are listed in the order of their general productivity under the prevailing farming practices, the most productive soils being at the head of the table.

TABLE 7.—*Productivity rating of soils in Mason County, Md.*

Soil ¹	Crop-productivity index : for—									
	Corn	Wheat	Oats	Rye	Tim- othy and clover	Alfalfa	Field beans	Pota- toes	Vege- tables ²	Vege- tables ² + fruit ³
Nester loam.....	70	100	80	80	75	80	60	70	50	80
Kent silt loam.....	70	100	80	80	75	90	60	60	50	80
Selkirk silt loam.....	60	100	80	80	75	80	60	50	50	60
Nester loam, rolling phase.....	70	80	80	80	80	80	60	70	40	70
Emmet sandy loam, smooth phase.....	70	80	70	80	40	80	60	90	40	70
Bergland loam.....	70	80	90	80	80	80	80	40	70	50
Emmet sandy loam.....	60	60	60	60	50	70	60	90	30	70
Otto silt loam.....	60	80	80	80	80	80	80	40	30	40
Antrim sandy loam.....	60	50	50	60	40	55	40	70	50	70
Fosco sandy loam.....	50	60	70	80	40	55	60	90	40	50
Otto sandy loam.....	50	50	60	80	50	55	80	70	40	50
Arenac fine sandy loam.....	50	50	60	80	50	55	60	70	40	50
Ottawa fine sandy loam.....	50	50	60	80	40	45	60	80	40	60
Munuscong sandy loam.....	50	50	60	50	80	45	70	70	60	60
Mancelona sandy loam.....	50	40	30	80	40	55	60	70	50	50
Granby sandy loam.....	50	40	30	80	45	45	70	60	60	40
Orenaw sandy loam.....	50	40	40	50	50	45	60	50	50	50
Montcalm sandy loam.....	40	40	40	60	30	35	60	60	40	50
Arenac loamy sand.....	40	40	40	40	40	35	40	60	30	40
Arenac loamy sand, rolling phase.....	30	20	20	50	40	35	40	60	40	40
Emmet loamy sand, smooth phase.....	40	20	20	60	30	30	40	50	40	40
Echo loamy sand.....	40	20	20	60	30	35	40	50	40	50
Ottawa loamy fine sand.....	40	20	20	60	30	30	40	50	40	50
Lupton muck.....	780	20	20	60	100	30	40	50	30	40
Houghton muck.....	780	20	30	40	100	40	40	40	20	20
Kalkaska loamy sand.....	780	20	30	40	10	30	40	40	20	30
Burned muck over sand.....	30	30	40	40	50	25	20	40	20	20
Emmet loamy sand.....	30	30	40	40	20	40	40	40	20	30
Saugatuck sand.....	20	20	20	20	20	55	20	30	10	10
Nester loam, steep phase.....	20	20	20	20	20	1	20	30	10	10
Roselawn loamy sand, smooth phase.....	20	20	20	20	20	1	20	30	10	10
Walkill loam.....	20	20	20	20	50	1	20	30	10	10
Maunee loam.....	20	20	20	20	50	1	20	30	10	10
Newton loamy sand.....	20	20	20	20	50	1	20	30	10	10
Roselawn loamy sand.....	20	20	20	20	50	1	20	30	10	10
Rubicon sand.....	20	20	20	20	50	1	20	30	10	10

Rubicon sand, slope phase.....	10	10	10	10
Rubicon fine sand.....	20	10	10	10
Emmet sandy loam, steep phase.....	20	10	10	10
Kerston muck.....	20	10	10	10
Montcalm sandy loam, steep phase.....	20	10	10	10
Wallace fine sand.....	20	10	10	10
Wearie fine sand.....	20	10	10	10
Kalkaska loamy sand, slope phase.....	20	10	10	10
Burned muck over clay.....	20	10	10	10
Rifle peat.....	20	10	10	10
Griffin sandy loam.....	20	10	10	10
Emmet loamy sand, steep phase.....	20	10	10	10
Ottawa loamy fine sand, broken phase.....	20	10	10	10
Newton loamy sand, drained phase.....	20	10	10	10
Saugatuck sand, drained phase.....	20	10	10	10
Grayling sand.....	20	10	10	10
Graying sand, slope phase.....	20	10	10	10
Bridgman fine sand.....	20	10	10	10
Greenwood peat.....	20	10	10	10
Dune sand.....	20	10	10	10
Coastal beach.....	20	10	10	10
Lake bluff.....	20	10	10	10
Made land.....	20	10	10	10

¹ The soils are listed in the approximate order of their general productivity under current practices, the most productive first.

² The productivity of each of the various soil types for each specific crop is compared to a standard, 100, which stands for the (or soils) of significant acreage in the United States for that crop. This productivity rating of the soils of Mason County is based on practices which include the use of some lime and commercial fertilizers. The ratings for the imperfectly and poorly drained soil types are based on conditions of drainage and management.

³ Vegetables doing best on highly organic soils; for example, onions, celery, lettuce.

⁴ Vegetables not requiring highly organic soils.

⁵ These indexes for fruits (and for vegetables) are not based on standard yields of reference but are only comparative for the soils. These indexes indicate only the comparative ratings of the soils in the county for pasture. Although these ratings are not productivity rating tables prepared for other soil survey reports—100 = 100 cow-acre-days—it is believed they are comparable. Cow-acre-days of pasture land. As used here, it is the product of the number of animal units carried per acre multiplied by the number of days the animals are on the land. For example, a soil type able to support 1 animal unit per acre for 360 days of the year rates 360, whereas another type able to support 2 animal units per acre for 180 days of the year rates 360.

⁶ These indexes refer to production of silage only.

NOTE: Leaders indicate that the crop is not commonly grown on the particular soil type.

The rating compares the productivity of each of the soils for each crop to a standard—100. This standard index represents the inherent productivity of the most productive soil of significant extent in the United States for that crop. An index of 50 indicates that the soil is about half as productive for the specified crop as is the soil with the standard index. Soils given amendments, such as lime, commercial fertilizers, and irrigation, or unusually productive soils of small extent, have productivity indexes of more than 100 for some crops. The following tabulation sets forth some of the acre yields that have been set up as standards of 100. They represent long-time average yields of crops of satisfactory quality on the better soils without the use of amendments.

Crop:		
Corn-----	bushels--	50
Wheat-----	do-----	25
Oats-----	do-----	50
Rye-----	do-----	25
Beans-----	do-----	25
Potatoes-----	do-----	200
Timothy and clover-----	tons--	2
Alfalfa-----	do-----	4 ¹

¹ Since publication of the Soil Survey of Oceana County, Mich., the standard yield used for alfalfa is 4 tons instead of 4½.

The crop indexes in table 7 refer to the productivity of the soil types under the prevailing farming practices in this county, which include the use of small quantities of commercial fertilizer and limestone. These indexes may differ from county to county, since practices of management and certain characteristics of soil types may vary from county to county.

The drainage considered for these ratings is that provided in practice in this county and is not optimum. In instances where no crop is grown on certain types of soils, as where no areas of certain soils are under cultivation, no ratings are given, and no ratings are given for fruit trees for the organic soils. Optimum drainage would change the places of some of the soils, especially Bergland loam, Munuscong sandy loam, Otto silt loam, Otto sandy loam, and other poorly or imperfectly drained soils. Even with optimum drainage, however, these soils would not equal Nester loam or Emmet sandy loam in the production of potatoes or tree fruits, because of their low position, lack of air drainage, and consequent inherent frostiness.

Because of a lack of definite information and data on yields, the indexes in table 7 for tree fruits, small fruits, and vegetables do not refer to yield standards. They are an attempt to portray the comparative productivity of the soils of this county and adjoining counties and are based largely on observations and interviews made in the progress of the survey. The ratings for pasture are of a similar character and are based primarily on the ability of the soil types to support a growth of Kentucky bluegrass (*Poa pratensis*) and Canada bluegrass (*P. compressa*).

The natural factors influencing the productivity of land are mainly climate, soil, and relief, or lay of the land. Management and the use of soil amendments are additional factors. Crop yields over a long period of years furnish the best available summation of those factors contributing to productivity, and they have been used largely

as the basis for the determination of the productivity indexes in the table. A low index for a particular crop may be due to some local condition of unfavorable relief, drainage, or climate rather than to a lack of fertility in the soil. It will be seen from the note at the end of the table that no rating is given if the crop is not commonly grown on the particular soil type. It should be understood that these productivity ratings are not to be interpreted directly into specific land values. They are based on the essentially permanent factors of productivity of the soils and their responsiveness to management, and little attention is given to the more transitory economic conditions of land value.

MORPHOLOGY AND GENESIS OF SOILS

Mason County lies in the northern part of the transitional zone between the Podzol soils of northern Michigan and the Gray-Brown Podzolic soils of southern Michigan. Only one member of the Gray-Brown Podzolic group is mapped. It is a soil developed from heavy silty clay parent material in the southern part of the county.

The parent materials from which the soils of this county have been developed are of glacial origin. In places these materials have been reworked and redeposited by the action of glacial-lake waters and glacial streams. Three rather distinct types of parent material occur separately, in combination with each other, or with minor variations.

The first type of material consists of heavy calcareous till clay, with massive structure and reddish-brown color. As a rule, only a small quantity of coarse gravel and boulders is mixed with this material, and in a few small areas it resembles lacustrine deposits rather than till.

The second type of parent material consists of sands, most of which are medium in texture, with smaller quantities of fine and coarse sand. These sand deposits in most places are more than 10 feet thick, and they occupy three different topographic positions, moraines, glacial outwash plains, and dunes. The sandy glacial drift, in part, contains a small amount of carbonates, and some limestone boulders are scattered through it. The associated outwash plains seemingly have a lower content of carbonate than the material in the moraines. Most of the sand of the dunes is fine and is high in quartz. Another variation consists of a layer of medium or fine sand, 2 or 3 feet thick, deposited by later wind or water action over the heavy clay till first described. A high water table, held up by the underlying clay, has prevented a well-drained soil from being developed, although a regional color profile has developed in some places. In this type of material, the development of a profile has been in the overlying sand.

The third distinct type of parent material is sandy clay glacial drift, generally containing sufficient clay and other material to produce a fairly well defined B horizon. This material generally is high in limestone, with a moderately large number of gravel, stones, and boulders mixed throughout. In color it ranges from light brown to pinkish red.

Factors and features influencing soil development are vegetation and relief, with the resultant differences in drainage or height of the water table. A high water table has retarded development to such

an extent in some places that the resultant soil profile has little resemblance to the regional profile, but in other places, where the water table is slightly lower, regional color profiles, with an ortstein layer have developed.

Two distinct types of forest cover, hardwood and pine, or coniferous, are associated with variations of the Podzol profile. The hardwood cover consists largely of sugar maple and beech, with smaller numbers of elm, basswood, ash, ironwood, cherry, hemlock, and a few white pine and red pine. All the pineland has been cut and burned over, but in large areas the stumps still remain, and the original forest evidently consisted dominantly of white pine and red pine, with possibly interspersed oaks or other hardwoods. In some places the pine trees were large and widely spaced, but dense stands of smaller pine trees were also common.

Following is a description of a profile of Emmet sandy loam, developed under hardwood vegetation, as observed in the southwest corner of section 35 of Pere Marquette Township:

- A. Very dark grayish-brown or nearly black finely divided and partly disintegrated organic matter composed of leaves, twigs, and pieces of wood, which is slightly acid in reaction and from 2 to 4 inches thick.
- A₁. 4 to 10 inches, lavender-gray or light-gray fine sandy loam or loamy sand which is very strongly acid in reaction. This layer is slightly laminated in place but readily breaks down to a friable pulverulent mass. The dividing line between this layer and the organic mat is abrupt, although a little sand is intermixed with the organic material and some organic matter is mixed with the upper ½- or 1-inch layer of the leached mineral material.
- B₁. 10 to 20 inches, dark brownish-yellow, umber-brown, or coffee-brown sandy loam that is strongly acid. A noticeable colloidal coating is on the grains of the material of this layer.
- B₂. 20 to 40 inches, mixed light-gray loam and somewhat red sandy clay or light sandy clay which is medium acid.
- C. 40 inches +, pale reddish-brown sandy clay or sandy clay glacial drift, which is calcareous.

A soil, such as Montcalm sandy loam, developed from similar-textured parent material under coniferous vegetation, differs from the soil described in having a thinner organic mat composed largely of pine needles, that is very strongly acid. The B horizon is thinner than that under a hardwood cover and is yellow or light yellowish brown rather than deep dark brown. This difference holds throughout the soils with a hardwood cover and those with a pine cover.

Kalkaska loamy sand and Emmet loamy sand have developed under vegetation similar to that growing on Emmet sandy loam, but they differ from Emmet sandy loam in topographic position and in texture, although the color profiles of all three soils are very similar. Rubicon sand and Roselawn loamy sand are soils developed under a pine cover, and they bear the same relationship to Montcalm sandy loam that Kalkaska loamy sand and Emmet loamy sand do to Emmet sandy loam. The same differences exist between Rubicon sand and Kalkaska loamy sand, Roselawn loamy sand and Emmet loamy sand, as between Montcalm sandy loam and Emmet sandy loam.

The Emmet soils developed from a parent material higher in carbonates and lime than the parent material of Montcalm sandy loam. It is possible that the parent material of Kalkaska loamy sand was higher in lime and carbonates than the parent material of Rubicon

sand, although the difference in this respect is not determinable by field methods.

Grayling sand, as mapped in this county, is a well-drained soil developed from deep deposits of medium sand, with quartz as the dominant mineral. No topographic map of this county is available, and the relative elevation of this soil, compared with that of associated soils is not known exactly, but in a few places there is an abrupt drop, ranging from 10 to 40 feet, from the adjoining soils to areas of Grayling sand. In some places Rubicon sand grades into Grayling sand, and in other places streams separate Grayling sand from the adjoining soils. A description of a profile of Grayling sand, as observed in the SW $\frac{1}{4}$ sec. 4, T. 20 N., R. 15 W., is as follows:

- Ao. A dark-brown organic layer, chiefly of oak leaves, from one-fourth to one-half inch thick.
- A₁. 0 to 1 inch, light-gray leached medium sand which is very strongly acid.
- B₁. 1 to 3 inches, yellowish-brown medium sand which is very strongly acid.
- B₂. 3 to 20 inches, yellow or slightly brownish yellow medium sand, very strongly acid in reaction.
- C. 20 inches+, grayish-yellow medium sand which is strongly acid to a depth of more than 4 feet.

The above profile was observed in an area where the forest vegetation consists of oak trees, none of which is more than 12 inches in diameter, and it seems doubtful that the area has ever been cut-over. Where a definite leached layer is not present the profile is as follows:

- Ao. A $\frac{1}{2}$ - to 1-inch organic layer, as in the profile described above, which is slightly acid.
- A₁. 0 to 3 inches, a mixture of light-gray medium sand and light-brown organic matter, which is very strongly acid.
- B. 3 to 20 inches, yellow or brownish-yellow medium sand which is strongly acid.
- C. 20 inches +, strongly acid grayish-yellow medium sand which becomes limy below a depth of 4 feet.

The development of all the intrazonal soils has been retarded by a high water table or excessive moisture. These soils are of three classes: (1) Soils in which the water table stands at or near the surface so that a dark-colored surface soil has developed over a drab, gray, or gray mottled with brown and red subsoil; (2) soils which generally have a dark coffee-brown ortstein layer; and (3) soils developed under poor or imperfect drainage, which have become naturally well drained but still retain the characteristic color profile of their former more poorly drained condition. This last condition is represented by Newton loamy sand, drained phase; and Saugatuck sand, drained phase. Some of these soils definitely developed under a marsh-grass vegetation, but they do not have the thick dark surface soil characteristic of dry Prairie soils in other parts of the State. It is possible that Grayling sand may have gone through this stage of fairly swift change from wet to dry conditions.

Old inhabitants state that considerable areas of Grayling sand never were forested and that other large areas supported only a sparse stand of jack pine ranging from 4 to 6 inches in diameter. The drained areas of the Newton and Saugatuck soils still support small clumps of short willows, and a few clusters of these willows grow on the areas of Grayling sand.

The drained phase of Saugatuck sand at present supports a cover of small oaks and jack pine as the predominant trees. It would seem

that this soil remained at a drainage stage, in which the water table was slightly beneath the surface long enough to develop a hardpan before the change to a well-drained condition. The Grayling and the Rubicon soils may have had a similar profile in one stage of their development.

Deposits of peat and muck comprise about 9 percent of the land surface of the county. The positions occupied by most of these deposits are old lake beds that have become filled with decayed vegetation. These areas have been forested long enough, that the upper 2 or 3 feet of most of the organic deposits are derived largely from woody vegetation.

Table 8 gives the results of mechanical analyses of samples of Emmet sandy loam and Nester loam.

TABLE 8.—*Mechanical analyses of two soils from Mason County, Mich.*

Soil type and sample No.	Depth	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay
Emmet sandy loam:	<i>Inches</i>	<i>Percent</i>	<i>Percent</i>	<i>Percent</i>	<i>Percent</i>	<i>Percent</i>	<i>Percent</i>	<i>Percent</i>
305724.....	2- 8	0.5	9.1	26.2	30.3	8.6	20.7	4.7
305725.....	8-22	.7	8.8	24.6	30.5	7.3	18.1	9.9
305726.....	22-48	.5	6.6	19.9	23.6	6.1	16.1	27.2
305727.....	48+	.7	10.2	29.9	36.0	5.6	4.7	12.9
Nester loam:								
305729.....	2- 6	.3	4.1	11.9	22.0	15.3	31.9	14.5
305730.....	6-12	.4	3.0	9.0	19.0	20.6	31.5	16.5
305731.....	12-24	.1	3.1	8.8	18.9	10.0	18.2	40.9
305732.....	24+	.4	2.7	7.5	17.0	10.6	23.3	38.6

SUMMARY

Mason County, with an area of 494 square miles, is located in the western part of the Lower Peninsula of Michigan and is bounded on the west by Lake Michigan. The winters are fairly long and the temperature is low for a period ranging from 4 to 6 months. The temperature seldom drops more than 5° or 10° below 0° F. and then for periods of only 1 or 2 days at a time. The summers are warm, but both summer and winter temperatures are moderated by the prevailing winds from Lake Michigan.

The Lake Michigan shore line provides an excellent bathing beach which, together with the numerous inland lakes and good roads connecting the county with large centers of population, makes the county a popular summer playground.

Three main types of agricultural activity are carried on—fruit farming, general farming, and livestock farming—as well as a combination of two or three of the main types of farming.

All types of farming are diversified, with several different sources of income on each farm. Apples, cherries, peaches, pears, and plums are the chief tree fruits grown, and strawberries, raspberries, and dewberries are the most important small fruits. Wheat, potatoes, string beans, cucumbers, field beans, and rye are the chief cash crops. The production of milk and cream is the most important branch of livestock farming. Large acreages of hay and smaller acreages of corn and oats are grown for consumption on the farm.

The heavy-textured soils and the imperfectly and poorly drained soils are used chiefly in various systems of general, dairy, and livestock farming. Sandy loam soils that are well drained, gently rolling, and situated near Lake Michigan are used largely for the culture of tree fruits. Fruit farming is one of the more profitable types of land utilization in areas having favorable climatic conditions in addition to suitable soil conditions, including position, relief, and drainage. Heavy-textured soils, or loams and silt loams, occupying smooth undulating land, and imperfectly and poorly drained soils are not suited to the growing of fruit trees but are good general and livestock farming soils.

Large areas of dry sand soils, deficient in essential plant nutrients as well as moisture, are not cleared, although the original tree cover has been cut, and the land has been burned over. Approximately 50 percent of the total area of the county consists of such soils unsuited to agriculture. The poorly drained soils generally are pastured or are used for the production of hay crops, although many acres are neither cleared nor pastured but are left as game cover and forest land, as also is a large part of the dry sand soils.

Most of the cultivated soils range in relief from nearly flat or undulating to gently rolling. On land having slopes of 15 or 18 percent, the use of tractors, binders, hay loaders, and other labor-saving machinery is somewhat difficult, but probably 90 percent of the land under cultivation is sufficiently smooth and free of stones for the economical use of all heavy agricultural machinery.

The soils in general are low in organic matter and medium in natural fertility, although most of them can be improved readily through the use of manures, commercial fertilizers, and lime.

The soils naturally fall into four groups: (1) Well-drained soils, (2) imperfectly drained soils, (3) poorly drained soils, and (4) miscellaneous land types. The well-drained soils are of two main classes, the first class including the sandy loams, loams, and silt loams, and the second class including the sands and loamy sands. The sands and loamy sands are as a class unsuited to agriculture, owing to deficiencies in moisture and essential plant nutrients.

The sandy loams, loams, and silt loams are the agriculturally important soils of the county. This subgroup includes some soils unsuited to extensive agricultural production, but more than 90 percent of them is under cultivation, and probably 90 percent or more of the agricultural products of the county is produced on them.

The imperfectly drained soils include some soils that are closely associated with the well-drained heavy soils and are agriculturally important. The sandy loam members of this group are good soils for the production of general farm crops, although they are not suited to the growing of fruit trees. In most places some artificial drainage is advisable for best results. The sand members of the group, however, generally do not require artificial drainage, but they are deficient in essential plant nutrients for the economical production of crops.

The poorly drained soils require artificial drainage for the production of crops and generally are classed as hay and grain soils. Nine percent of the county consists of organic soils which are classed as

poorly drained soils. Most of the organic soils are not cleared, although most of the areas of these soils have high potential value as grain and forage soils. The high cost of clearing and control of the water table tend to discourage extensive use of the organic soils for crops.

Nester loam and Selkirk silt loam are heavy-textured soils with heavy red clay subsoils. The plow soil is strongly acid, but, at a depth ranging from 24 to 36 inches, lime is abundant. These soils generally are free of stones and boulders, and their relief normally is smoothly undulating. They are well drained, but Selkirk silt loam is inclined to be slow in drainage and would be improved by artificial drainage. These are the principal soils for the production of hay, corn, and grain.

Emmet sandy loam has a loose friable sandy loam surface soil underlain by friable sandy clay which continues to a depth ranging from 2 to 3 feet. The upper part of this soil is acid, but the substratum, at a depth ranging from 3 to 4 feet, is calcareous. The relief ranges from undulating to strongly rolling, with gradients ranging from 7 to 15 percent. Some areas of this soil are smooth and suited for farming, whereas others are too steep for economical agricultural production. This soil is well drained and does not require artificial drainage. Most of the fruit trees are on Emmet sandy loam and its phases.

Iosco sandy loam and Ogemaw sandy loam consist of a 2- or 3-foot layer of sand and sandy loam over impervious clay. They are commonly called hardpan soils, as they contain a reddish-brown or coffee-brown slightly cemented layer between the plow soil and the clay substratum. Both soils are imperfectly drained, but Iosco sandy loam is the better drained. The Iosco soil shows little improvement through artificial drainage, but the Ogemaw soil requires some artificial drainage. These soils are closely associated with Nester loam and Selkirk silt loam and are important soils, as they are similarly cropped.

Grayling sand, Rubicon sand, Roselawn loamy sand, Kalkaska loamy sand, and Emmet loamy sand are extensive soils, but, because of deficiencies in moisture and essential plant nutrients, they are not adapted to the economical production of agricultural products.

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**This soil survey is a contribution from
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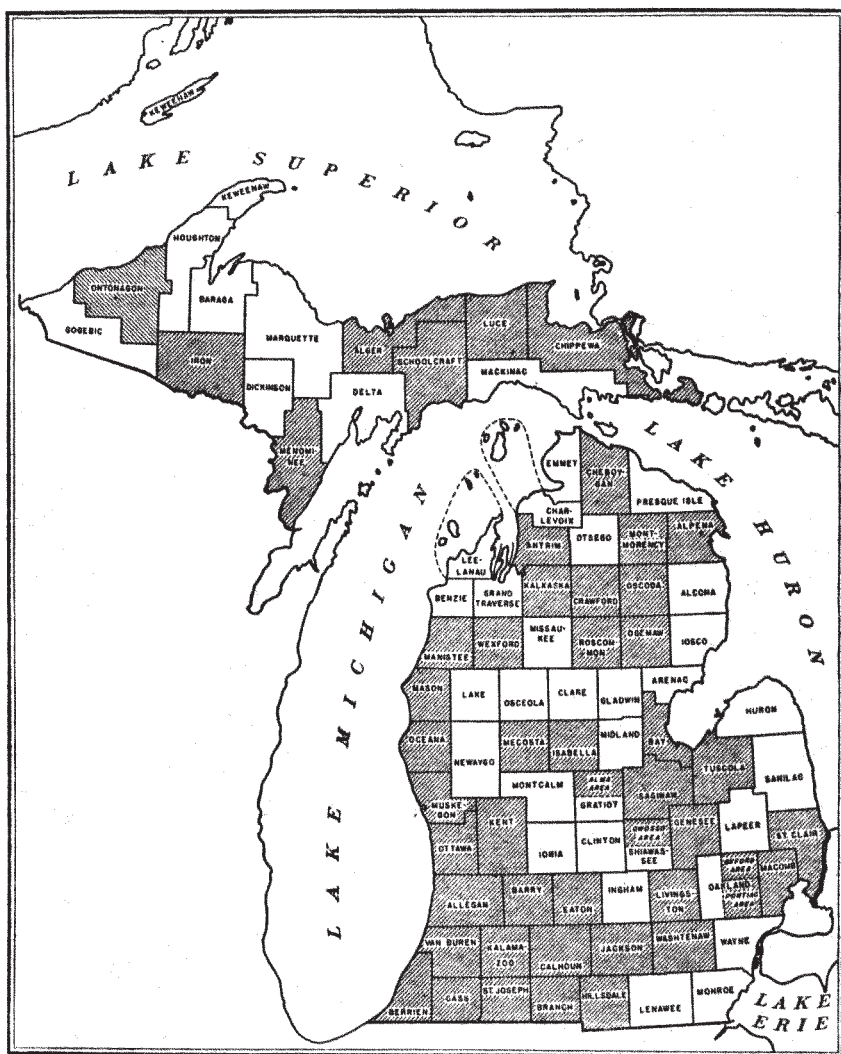
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Areas surveyed in Michigan shown by shading. Detailed surveys shown by northeast-southwest hatching; reconnaissance surveys shown by northwest-southeast hatching.

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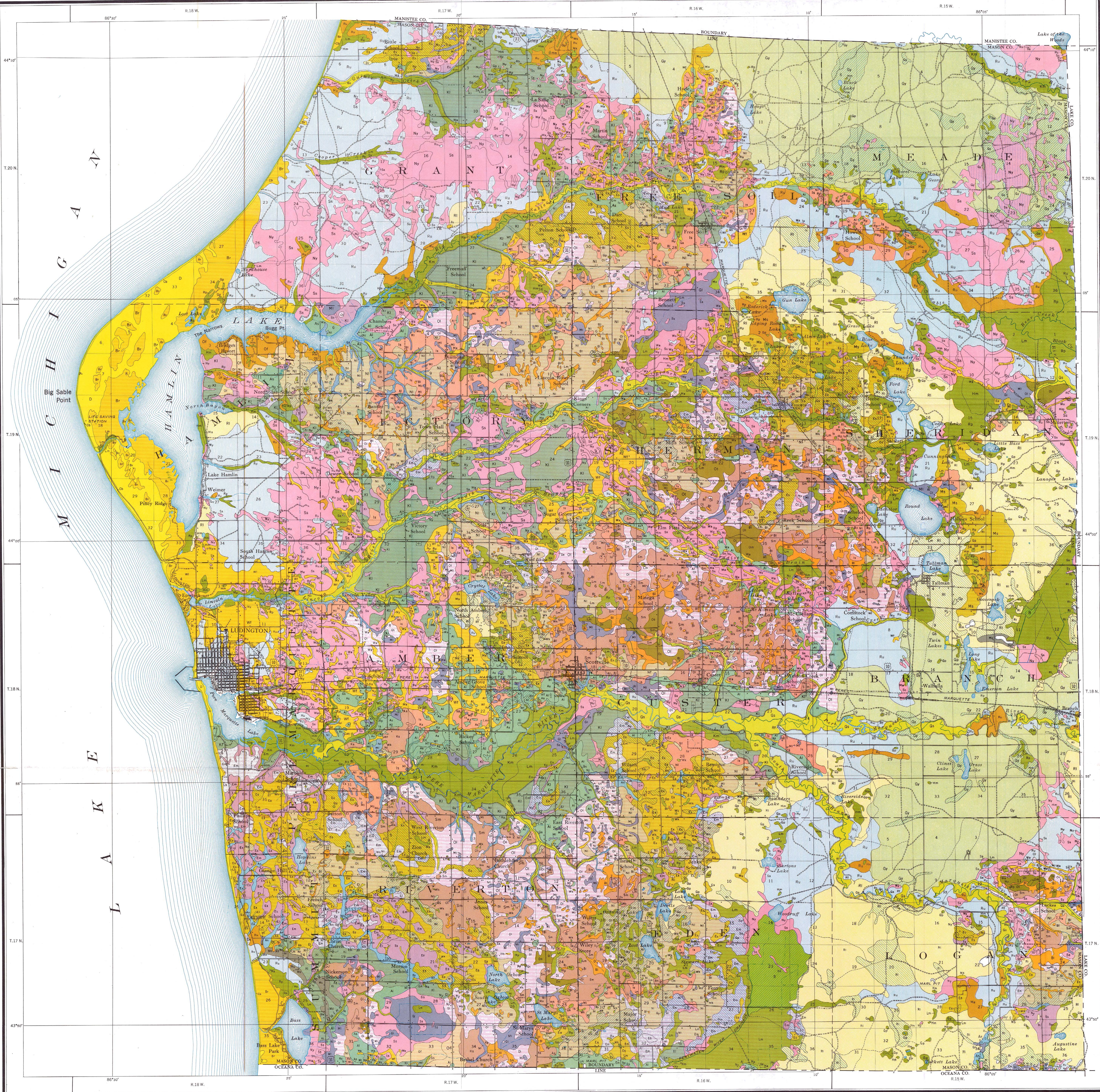
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LEGEND

Antrim sandy loam An	Grayling sand Gy	Newton loamy sand Ny	Selkirk silt loam Sm
Arenac loamy sand Al	Slope phase Gy	Drained phase Ny	Wallace fine sand Wa
Rolling phase Al	Iscos sandy loam Is	Ogemaw sandy loam Ol	Walkill loam Wk
Arenac fine sandy loam As	Kalkaska loamy sand Kl	Ottawa loamy fine sand Of	Weare fine sand Wf
Bergland loam Bl	Kl Slope phase	Broken phase Of	Coastal beach Cb
Bridgman fine sand Br	Kent silt loam Ks	Ottawa fine sandy loam Od	Lake bluff Lb
Echo loamy sand El	Mancelona sandy loam Mc	Otto sandy loam Om	Made land Md
Emmet loamy sand Em	Maumee loam Ma	Otto silt loam Ot	Burned muck over clay B
Smooth phase Em	Montcalm sandy loam Ms	Roselawn loamy sand Rl	over sand Houghton muck Hm
Steep phase Em	Steep phase Ms	Smooth phase Rl	Kerston muck Km
Emmet sandy loam Es	Munsee sandy loam Mi	Rubicon sand Ru	Lupton muck Lm
Smooth phase Es	Nester loam Ni	Slope phase Ru	Greenwood peat Go
Steep phase Es	Rolling phase Ni	Rubicon fine sand Rf	Rifle peat Rp
Granby sandy loam Gl	Steep phase Ni	Saugatuck sand Ss	Gravel pit
Griffin sandy loam Gs	Dune sand D	Drained phase Ss	

Note that similar soils are shown with the same color but with different letter symbols.

CONVENTIONAL SIGNS

CULTURE (Printed in black)	RELIEF (Printed in brown or black)